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14. ABSTRACT

This report results from a contract tasking Dr Michel Israel, Foundation Faraday, as follows: The contractor will compile data clarifying East European criteria for radiofrequency radiation (RFR) standards. The contractor will analyze studies which are significant and which can be reproduced in Western laboratories; will recommend areas needing further research; will consult with East European experts to document their different criteria of standards; and will report on any common viewpoints or tangents between different criteria for use in normalizing international RFR standards

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Introduction

This report is worked out on the basis of the presented in the contract:

- Aim of the project;
- Main tasks;
- Expected Results;
- Deliverables.

They are listed hereafter.

The **AIM** of the study is to find a way for reaching an agreement between different schools for developing standards, and more precise: to find a way how the specialists in West Europe, USA, Canada, Japan, etc. should understand the criteria of the East European Standards.
To achieve this aim we planned:

- to search East European studies which are significant, and which could be reproduced in other laboratories in the West;
- to organize a working group for discussing different criteria of standards,
- and to find common viewpoints and tangents between different criteria of standards to be used for reaching agreement in developing standards in future.

Working Program:
Task 1. *Review of some significant studies used for standard development from the East for future proposal to replicate.*
Task 2. *Developing of working groups from East Countries for involving them in an international standard harmonization process. Creating a database for such specialists for future collaboration.*
Task 3. *Organization of two seminars for the WGs for standard harmonization in the field of RFR.*
Task 4. *Description of the method and way for setting standards in the past - in committees formed by some East European countries.*

Deliverables:

1. A report for organizing the international WG for reviewing the publications in EECs.
2. A database including publications of EECs.
3. A report for organizing WG including key specialists from EECs for open discussion with the western scientists a new framework of international standards.
4. A report of seminars with WGs discussion.
5. A report reviewing key publications in EECs on developing standards with a suggestion for replication of key studies.
6. A proposal for a new guide for RFR standard with links for harmonization worldwide.

7. Short report and publication discussing the methods and ways for developing standards in the EECs in the past.

As it was stated in the Interim Report, the Project was developed on the basis of:

- studies conducted individually by the Bulgarian team;
- discussions in a working group, involving Bulgarian specialists – participants in the Project;
- meetings and discussions in international working groups at conferences in Varna (Bulgaria) and Seoul (Korea) in 2001;
- processing and analysis of the responses to a questionnaire, developed by M. Israel, team leader, and submitted to the participating countries for discussion and responding.

The **"Questionnaire"** has been developed from the Bulgarian team, using suggestions from the consultants. **In Annex – Questionnaire** are listed all the questions sent to the participants.

The results refer to the responses supplied by specialists from:

Bulgaria
China
Czech Republic
Hungary
Poland
Russia
Turkey
Yugoslavia.

Standpoints provided by specialists from the above countries, as well as published articles, materials, standards, applied in Annexes below, are covered.

Key words: radiofrequency radiation (RFR), standard development, criteria for exposure limits, database, replication, tangents, framework for standards

ANNEX - QUESTIONNAIRE

QUESTIONNAIRE AND ACTIVITIES

1. Database for published studies used for standard development in your country.

2. Proposals for individual research studies (published) with good protocol/design of the study. Requirements for such studies include:
   - good measurements and exposure assessment;
   - dosimetry – evaluation of the time duration, energy, induced currents, modeling, evaluation of the field strength inside the tissue, SAR (exp. one of them);
   - to have sham exposures, double blind exposures;
   - strictly observed requirements of good laboratory practice (GLP) and quality assurance (QA);
   - metrology requirements;
   - used adequate statistics methods;
   - contents including Objective, Hypothesis, Methods, Measurement and Dosimetry, Exposure Assessment, Experimental Protocol and Data Analysis, Discussion, Conclusion;
   - adequate control groups.

3. A list of specialists working in the field of standard development for RFR, being main factors for developing of the existing standards in your country, and being also the philosophers of the criteria of the standards available.

4. A list of specialists working in the field of standard development in your country to be included in the standard harmonization process worldwide. Requirements for choosing these specialists:
   - open minded;
   - to be open to accept another ideas and for discussion;
   - language skills (mainly English);
   - active working in the field of RFR exposure and risk assessment for standard development.

5. What was the way for developing the existing standard limits in your country? What kind of investigations, studies, discussions, working groups, etc. have been made to reach these standards? What kind of model have you used for developing standards? Please, number key researchers (also studies) in this field having actively participated in this process in the past.

6. What are the criteria and rationale used in your standards? Please, describe for:
   - the frequency ranges;
   - the exposure limits;
   - biological criteria and rationale;
   - pulsed fields (yes/no) and criteria;
   - parameters;
   - kind of studies for reaching these criteria;
   - safety factors;
   - uncertainty, etc.

7. Which parameters could be a basis for standard harmonization in future?

8. How do you adopt the criteria of the Western standards? What is your opinion about such criteria? Do you intend to accept their criteria in your standards?

9. What are your ideas for future development of standards:
   - in your country;
   - in the East European criteria;
   - worldwide?

10. Where do you see possibilities for agreement between different schools for developing standards? Please, show close viewpoints and tangents between different schools (East and West).

11. What kind of problems do you observe in the field of the standard harmonization in the world?

12. What do you think about the "windows" and "resonance" effects? Do you think they could be included in the criteria for standards?

13. What is your opinion about (your definition for):
    - long-term and short-term effects;
    - thermal and non-thermal effects;
    - informational effects;
    - adverse effects.

    Is it possible these effects to be used for standard criteria? If yes, please mention where.

14. Do you think that headache, cardiovascular changes, effects on EEG, blood pressure, heart rate, sleep disorders, mental problems, changes in the autonomic nervous system could be factors to define "adverse effect" and to use them as criteria for standard development? Add additional changes in organism if you think they are important for human health.

15. What is your criticism to the ICNIRP Guidelines?

16. How should precautionary approaches be devised if needed? Should they be included in standards?

17. What do you think about the questions for establishing a harmonized framework proposed by WHO in the Progress Report 1998/1999 of the International EMF Project:
    - Criteria to be used to evaluate research results;
    - Detailed requirements for scientific rationale to support limits;
    - Model for developing standards;
    - Methods for determining compliance;
    - What to do with isolated data points at specific frequencies;
    - When research data are absent in particular frequency ranges, how and with what degree of confidence can results be extrapolated to other frequencies or intensities;
    - Applicability and extrapolation of animal or cellular studies to humans;
    - Should one standard cover the whole frequency range from 0 to 300 GHz;
    - Safety factors: should they address scientific uncertainties in the fundamental research or imprecision in the techniques used for exposure assessment and should they also allow for gaps in knowledge;

- Should standards be one or two tiered – i.e. differentiate between occupational or controlled exposure and general population or uncontrolled exposure;
- What about social and economic impacts; should they be considered;
- Should they be in a form that methods for determining compliance are made easier.

Report on Task 1: *Review of some significant studies used for standard development from the East for future proposal to replicate*

In **"Results"** are listed several studies carried out by Eastern European scientists for standards development.

Annex 1 (Task 1) presents the full texts of the articles prepared by Prof. Szmigielski and M. Israel. The other papers are in Russian and, if necessary, they can be translated in English and submitted for replication.

We have been assured that Russia has available about 50 articles that have been used particularly for elaboration of standards. They will be submitted for review at the EMF Conference in September 2002. Other significant papers that I know, some of them with the protocols, necessary for replication, present the studies of ex-Czechoslovakia in the 70s and 80s of the past century. Unfortunately, the authors of those studies no longer work in the field of electromagnetic effects (particularly Jan Musil, who has retired) and I shall not be able to include these papers in the presented list.

The review of East-European papers is made based on the requirements, set in the material of Repacholi MH and Cardis E (1999) – *Criteria for EMF Health Risk Assessment*, Radiat. Prot. Dosim., 72: 305-312, and is conformed with the requirements, developed and presented by the Bulgarian team (Annex 2 to Task 1).

Here we shall discuss some viewpoints concerning the possibility to replicate past studies. Such opinions were shared by specialists from the Eastern countries, particularly from Russia, Poland, Bulgaria.

First of all it should be outlined that the studies conducted for the purposes of hygienic standardization in East-European countries were performed under observation of a design/protocol that were very close to the requirements to similar studies at present.

The opinion of Russian specialists mainly is that the replication of "old" studies might face serious difficulties, even might be unrealizable. There are lots of reasons for this. One of them is, for example, that the studies were conducted in radiation conditions, similar to those found in practice – at the workplace and/or settlements. The experiments covered also exposures, particularly associated with emitters that were most popular in practice. The observation of these requirements leads to the following possible results:

a) direct achievement of the exposure effect by appropriate design plan;

b) direct transfer of experimental data for hygienic standardizing for the particular irradiation conditions;

c) setting limits for EMF by particular frequency ranges for particular irradiation conditions, used in practice.

This approach bears its negatives as, for example, the impossibility to develop criteria for setting limits in the overall frequency range – the results must be extrapolated.

Another problem at planning the replication of past studies is the impossibility to reproduce all accompanying factors to the major EMF irradiation. Some of them are associated with the selected subjects (animals, humans), other – with the particular

emitter (signal type, harmonics), yet others – with the environmental factors (background factors), as well as with the particular approach and procedure of the studies. All these parallel factors have, most often, not been described in the publication and some of them cannot be described in a paper. There are a number of reasons for that: restricted volume of the paper, minor requirements to the description of the study design (some journals do not require it although they are peer-reviewed).

As for the criticism to East-European publications in the period 1960-1990 concerning lack of description of qualitative dosimetry, it could be stated that at that time (particularly on the first 15 years of the period) such dosimetry is not present in almost all publications all over the world, but this does not mean that the researchers have not accounted for all requirements necessary for keeping to good laboratory practice. Besides that, the majority of studies have been conducted in conditions enabling exposure assessment which value could be re-calculated to criteria required at present -SA, SAR or other dose parameters.

The third problem concerning the replication of past studies refers to ethic aspects and copyright. We shall not be discussing this problem here. We shall only mention the fact that the author should give his/her consent for a similar reproducing and for participation in the repeated experiment.

Nevertheless, we are reminding again the opinion shared by the majority of East-European researchers that the replication of past studies is a complex issue that might not lead to a positive result, i.e. the conditions of the experiment might not be reproduced. This respectively could result in false interpretation of the final results of the study.

Despite of this, we prepared several studies to be discussed for future replication. Approximately 50 studies we will receive (as full protocols) additionally, during the meeting in Russia in September this year.

Annex 2 (Task 1) presents two types of requirements compiled by the Bulgarian team:

- For existing past studies: **Requirements for review of papers for replication. Necessary parameters/criteria**
- Perfect requirements to conducting a study for the purposes of setting hygienic standards for EMF: **Ideal case of protocol/design of EMF effect study with a view to replication (maximal requirements)**

The latter presents the "ideal case" and is practically unrealizable. The requirements could be used (after additional further development) as criteria for an "ideal" study.

The simplest requirements for reviewing literature connected with dosimetry are presented in **Annex 3 (Task 1): Criteria for reviewing literature in the field of RFR standards development Basic Criterion for the RFR Exposure.** These requirements are directed more to the type of the irradiating system, not to the object of exposure.

Annex 4 (Task 1) presents a database of literature in the field of EMF exposure conducted by East European teams. Unfortunately, most of them are in Cyrillic (Slavonic languages), and it was impossible to translate the most important of them for the short time of this project. It would be possible to continue the work in this direction if there is an interest for better understanding of these studies.

For collection and analyzing the literature database an information system was developed, described in details hereafter.

The database analyzing program is based on the software products: Microsoft Access-2000, V-BASIC and SQL Server 7.0.

The database includes international Eastern and Western papers and documents about standards in the field of RFR. The database allows specific search by keyword and calculations of SAR for some common known media.

Defining of the basic principles of database analysis:

The database is created on two basic principles for two different types of users, first type are users without special knowledge in the area of EMF action (Propaganda and information in the risk assessment); the other group are users specialists in the area (They can obtain important information about current meetings and specialized papers selected by keyword, date and first author).

The database collects information related to a particular subject or purpose such as tracking papers in the area of standards in the field of RFR or maintaining of information for investigations in the area. An important part of the database are objects like: tables, queries, forms, reports, macros and modules.

Our database includes several types of objects according of the type of information storage:

- Objects stored in the Access project file: forms, reports, macros and modules;
- Object stored in the Microsoft SQL server database: tables, table properties (such as indexes, triggers and keys), views, stored procedures, and database diagrams.
- Data access pages that are shortcuts (displayed in the data base window) to corresponding HTML files stored in the file system
- Information for another application, such as a chart (graph) or a drawing.
- To make data available on the Internet or an Intranet for interactive reporting, data entry, or data analysis, the user could be use a data access page. Our database retrieves the data from one or more tables and displays it on the screen with the layout that you could choose. Users could interact with the data by using features on the GUI-based data access page.

The presented database could include information, which is imported directly, linked or input through GUI (based on V-Basic) by user or system administrator of the server. In the database it is possible to make changes in information if it is needed. Internet access could allow many people to share expressions and information about EMF standards.

Our database has several sources for transfer of information:

Importing data

Importing data creates a copy of its information in a new table in our database.

The source table or file is not altered in this process.

When importing data, you can't append data to existing tables (except when importing spreadsheet or text files). However, once you have imported a table, in the database you can perform an append query.

You can also import database objects other than tables, such as forms or reports, from Access database of Access project.

Linking data

In our database, linking data enables you to read and in most cases, update data in the external data source without importing. The external data source's format is not altered so that you can continue to use the file with the program that originally created it, but you can add, delete, or edit its data by using Microsoft Access as well. You can link a table only in an Access database, not an Access project.

Relational database

Presented information in our database has many related tables selected by factors, ranges, parameters of the environment and criteria for assessment.

When each piece of information is stored in only one table, you update it in one place. This is more efficient, and it also eliminates the possibility of duplicate entries that contain different information.

Each table should contain information about one subject.

When each table contains facts about one subject, you could maintain information about each subject independently from other subjects.

Our database allows using Microsoft Access analysis tools. Analyzing of existing information into database by:

- Calculations;
- Special presentations.

Our group is in the process of development of expert system for RFR standards.

Our database includes information by following areas:

- Frequency of RFR
- General population and occupations
- Bulgaria and other countries
- Precautionary approaches
- Criteria for risk assessment
- Parameters
- Type of regulation (standard, law, ordinance, etc.).

Annex 5 (Task 1) includes details of the program for database collecting and analysis.

Results/Deliverables No.2 and 5:

Our questionnaire gives us only an orientation about the studies completed before, and having good protocol for replication. We submitted here, in the presentation of ***Task 1*** some of these studies. Others could be received translated by the authors in future – at the time of the Russian Meeting in September 2002, and later. Some of the studies are the following:

Lobanova EA, Goncharova AV

"Influence of 191 and 155 MHz radio frequency range of electromagnetic fields to conditioned reflexes activity of animals". About biological effects of radio frequency electromagnetic fields. Works of Electromagnetic Fields of Radio Frequencies Laboratory of the Institute of Occupational Hygiene and Occupational Diseases of AMS of the USSR, Release 3, Moscow, 1968, pp. 76-80. (In Russian)

Tolgskaja MS, Fukalova PP
"Morphological changes in the organism of experimental animals, exposed to 155 and 191 MHz radio frequency electromagnetic fields". About biological effects of radio frequency electromagnetic fields. Works of Electromagnetic Fields of Radio Frequencies Laboratory of the Institute of Occupational Hygiene and Occupational Diseases of AMS of the USSR, Release 3, Moscow, 1968, pp.123-128. (In Russian)

Gordon ZV, Fukalova PP, Kitsovskaja IA, Bereznitskaja AN, Pankin AA
"Experimental studying of biological effects of low intensity radio frequency electromagnetic fields", Occupational hygiene and biological effects of radio frequency electromagnetic waves. Materials of the Third All-Union Symposium, June, 24-28 1968., Moscow, 1968, pp. 39-40. (In Russian)

Markov VV
"Influence of continuous and interrupted exposure of microwaves to changes of weight and blood pressure of animals in chronic experiment." About biological effects of radio frequency electromagnetic fields. Works of Electromagnetic Fields of Radio Frequencies Laboratory of the Institute of Occupational Hygiene and Occupational Diseases of AMS of the USSR, Release 4, Moscow, 1973, pp. 71-75. (In Russian)

Grigoriev, YuG, Lukianova SN, Makarov VP, Rynskov VV, Moiseeva NV
"Motor activity of rabbits in conditions of chronic low intensity pulse microwave irradiation". J. Radiation Biology and Ecology, Russian Academy of Sciences, 1995, Vol. 35, No.1, pp. 29-35. (In Russian, Abstract published in English).

Szmigielski, S, Sbicziewska E, Kubacki R
"Dysregulation of autonomic control of cardiac function and shift of diurnal rhythms of blood pressure in workers exposed to RF electromagnetic fields". Research Grant 4P-05D-01111/96 from the National Committee of Scientific Research in Poland, and by the European Commission INCO-COPERNICUS Project ERB CT15 IC980303 from DGXII in Brussels, Belgium (In English).

Israel M., Tomov P.
"Epidemiological study of the effect of radiofrequency radiation on operators in radio, TV and relay stations". Research Grant, Ministry of Health, Bulgaria, 1992. Proceedings of the Eastern European Regional EMF Meeting and Workshop "Measurements and Criteria for Standard Harmonization in the Field of EMF Exposure, and WHO EMF Standard Harmonization Meeting", Ed. M. Repacholi and M. Israel, Sofia, Publ. Foundation "Faradey", 2002, pp. 145-154.

Full text of the last two of them (in English) – in **Annex 1 (Task 1).**

Deliverable No.2: in **Annex 4 and Annex 5 (Task 1).**
Deliverable No.5: in the text above.
Additional results here are the development of:

- For existing past studies: **Requirements for review of papers for replication. Necessary parameters/criteria**
- Perfect requirements to conducting a study for the purposes of setting hygienic standards for EMF: **Ideal case of protocol/design of EMF effect study with a view to replication (maximal requirements)**
- **Criteria for reviewing literature in the field of RFR standards development. Basic Criterion for the RFR Exposure**
- **Database for collection and analyzing of standards in the field of RFR**

Dysregulation of autonomic control of cardiac function and shift of diurnal rhythms of blood pressure in workers exposed to RF electromagnetic fields.

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Dysregulation of autonomic control of cardiac function and shift of diurnal rhythms of blood pressure in workers exposed to RF electromagnetic fields.

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Abstract.

Biological effects of exposure to low-level, non-thermal radiofrequency (RF) fields were reported in different experimental systems *in vitro* and *in vivo,* however health risks and clinical relevance of these effects remain unknown. RF radiation at non-thermal intensities is considered as a relatively weak environmental/occupational factor and its bioeffects can be in most cases effectively balanced by trigerring of adaptative, compensative and/or regenerative mechanisms of the responding physiologic systems. There are no convincing data which confirm the possibility of development of specific diseases which could be causally linked to long-term exposures in RF fields, however there exist reports on increased risk of various functional abnormalities in subjects who work in RF environment.These fumctional abnormalities may be, at least partially, related to bioeffects of RF exposures which develop in the central nervous system. One of the possible outcomes of such effects may be dysregulation of autonomic control of various physiologic systems, including the cardiovascular system.

Some time ago we reported increased number of slight, subclinical ECG abnormalities, accompanied by symptoms of sympathicotony in heart rate variability (HRV), lowered day/nigh ratio of blood pressure and heart rate (Bortkiewicz A et al.: Dysregulation of autonomic control of cardiac function in workers at AM broadcasting stations (0.783 - 1.503 MHz). *Electro- Magnetobiology.* 1995;14:177-192), as well as shifts in diurnal rhythms of blood pressure and heart rate (Szmigielski S et al.: A shift of diurnal rhythms of blood pressure and heart rate in workers exposed to radiofrequency electrmagnetic fields as a symptom of dysregulation of the autonomic control of the circulatory system. *Blood Pressure Monitoring.* 1998; 3; 323-330) in a group of 77 workers of AM radio broadcasting stations who were exposed to 0.7-1.5 MHz RFs.

In the present study a group of 38 workers of radio transmitting centres (RTC), exposed to 10-30 MHz RFs, were examined with identical cardiological tests (ECG at rest, HRV, 24-hr Holter ECG, 24-hr ambulatory blood pressure – ABP), as the above mentioned wotkers of AM radio broadcating stations. RF exposure was monitored during whole 12-hr shifts and expressed in maximal levels (E_{max}), average levels (E_{av}) and time of exposure (T_{exp}) during the shift. From these data daily exposure dose rates for the shift (D_{sf}) and life exposure dose rates (D_{lf}) were calculated. It was found that during the 12-hr shift individual workers were exposed in RF fields in series of 3-5-min. periods, counting for a total exposure time of 0.5 – 2 hr per shift. Individual exposure levels differed considerably (E_{max} from 9 to 174 V/m; E_{av} from 0.5 to 11.4 V/m) with the daily exposure dose rates for the shift ranging from 22 to 3120 $(V/m)^2$ x h. With such large individual differences in RF exposure levels the most conclusive relations between the exposure and results of cardiac tests could be obtained by multistep correlation of single parameters. Statistically significant correlation with RF exposure parameters (D_{sf} and E_{av}) was found for HRV (fast/slow component ratio), HR and BP day/night ratio and parameters of BP and HR diurnal rhythms (acrophase and amplitude, but not mean value). In general, the results indicate dysregulation of autonomic control of cardiac function with shift toward sympathicotony, a phenomenon similar to that observed in workers of AM radio broadcasting stations, who are exposed to lower frequencies of RFs (0.7-1.5 MHz).

From results obtained in these two independent studies, which used 115 RF-exposed workers, we conclude that multiyear occupational exposure to RFs may lead to dysregulation of autonomic control of cardiac function and cause increased risk of development of functional symptoms of cardiac liability. However, clinical relevance of these findings is not firmly established and an increased risk for cardiac pathology could not be established in the tested material.

Introduction

Human organism is considered as a genetically pre-programmed self-sustaining mechanism, controlled by three regulatory systems – nervous, immune and hormonal (Fig.1). These three systems, equipped with a potent set of adaptative, compensative and regenerative mechanisms, can regulate function of internal systems under different harmful environmental conditions. In fact, efficiency of the three regulatory systems of the organism and capacity of their adaptative, compensative and regenerative mechanisms determine health status of the organism and its resistance against influence of harmful environmental and occupational factors (Fig.2). There exist numerous data which indicate that long-term occupational exposure of radiofrequency (RF) EMFs may result in development of various non-specific symptoms related to funcional changes in certain systems of the body, including slight abnormalities in cardiac function.

RF energy can penetrate inside human body and induce electric currents, which may be responsible for various effects in the organism. One of these effects is non-specific stress reaction. The basic of such reaction is the interaction of energy with cells, the influence transmission of signals and reaction of sensitive targets [6, 11]. The major place, which reacts on stress symptoms, is hypothalamus. The hypothalamus performs the control funtion for the para-sympathetic and sympathetic systems, which ones are responsible for the autonomic regulation of many organs and systems in human organism, among other things cardiovascular systems [13]. On the other side, the hypothalamus, with its ESSOC (Endogenous Self-Sustaining Oscillatory Clock) mechanisms triggers and controls the circadian (about 24-hr) cyclic changes of most parameters of the cardiovascular system with their maxima during day-time and minima at night. Therefore, RF EMFs may be one of the factors, which influence the synchronization of different biological rhythms. Biological rhythms (circadian, diurnal etc.) are a basic property of living matter from subcellular particles to the human body. They play a very important role in everyday life in health as well as in disease [3, 5, 14]. Fig.1 summarizes the possible mechanisms leading to development of functional changes of the cardiovascular system in EM-exposed subjects. These functional changes result mostly from dysregulation of the autonomic control of the system; by itself, the symptoms are not considered as cardiac pathology, but may pose an increased risk of development of certain cardiovascular diseases.

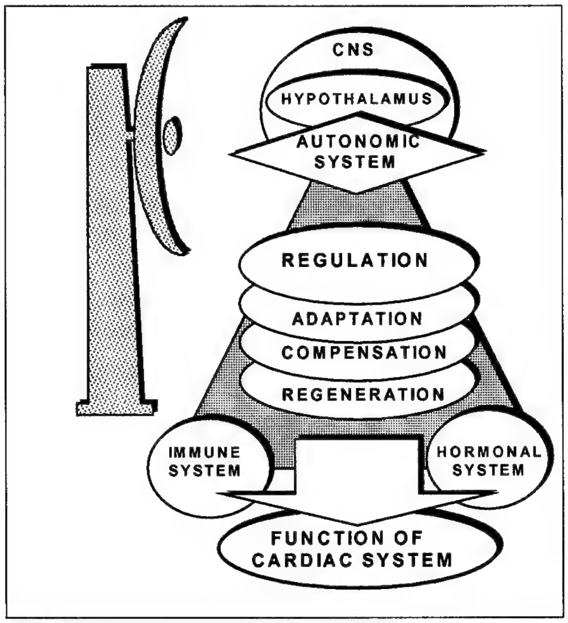

Figure 1.

Possible mechanisms leading to development of functional changes of the cardiovascular system and shifts of diurnal rhytms in subjects exposed to electromagnetic fields.

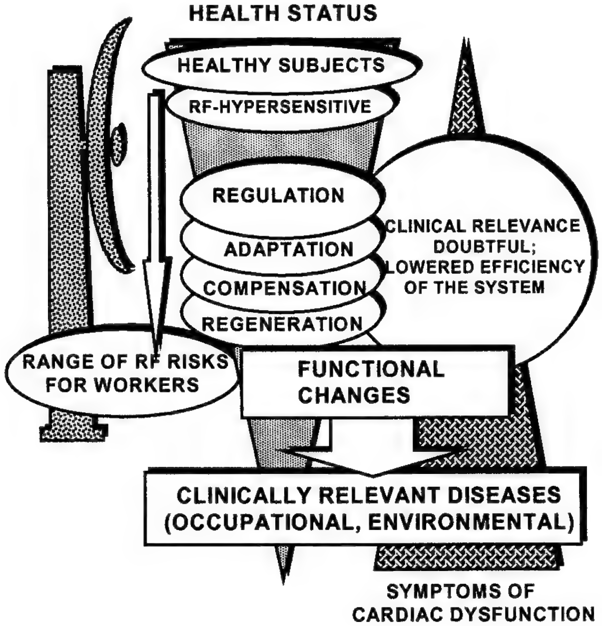

Figure 2

Development of symptoms of cardiac dysfunction in subjects exposed to electromagnetic fields.

In our previous studies [1, 2, 12] we documented a dose-dependent increase in number of functional ECG abnormalities in a group of workers of middle-wave radio broadcasting stations, exposed to 0.7 - 1.5 MHz RFs. The most frequently found effects

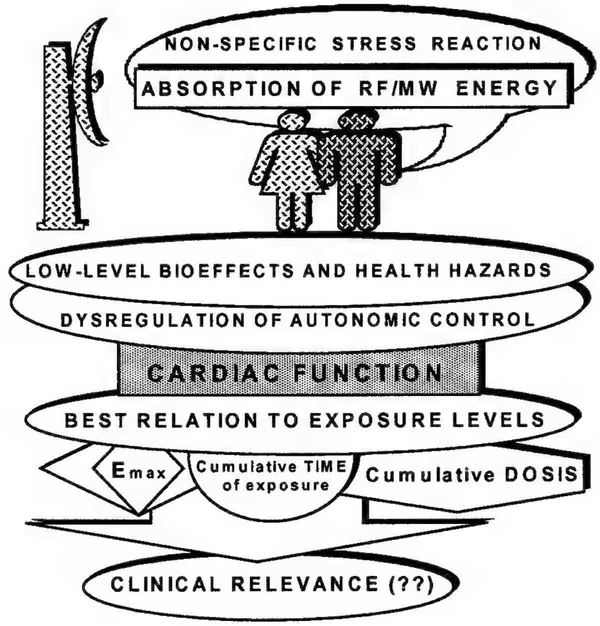

Figure 3.
A concept of the present study on dysregulation of autonomic control of cardiac function in workers of radio transmitting centres exposed to 10-30 MHz RFs.

included lowering of the day/night BP and HR ratio with negative correlation with RF exposure levels of workers [1, 2]. These findings suggested that the multiyear exposure of workers in relatively strong RF EMFs may additionally lead to desynchronization of certain natural diurnal rhythms, mainly of those rhythms which are controlled by the autonomic nervous system.

In the literature there exist experimental data indicating that exposure of animals in controlled EMFs may result in desynchronization of circadian rhythms [8, 9], which leads in turn to disturbances in function of certain organs and systems.

In the present study we examined cardiac function in another group of workers exposed to RF radiation. Personnel of radio transmitting centres (RTC), exposed during work to 10-30 MHz RFs, has been monitored during the whole 12-hr shift to assess the RF exposure and thereafter underwent cardiac examination which allowed to determine parameters of autonomic regulation of cardiac function, including heart rate variability and diurnal rhythms. In this study we tried to find best possible relations of abnormalities in cardiac function with exposure parameters (maximal and mean levels of exposure, time of exposure, daily dose of exposure) to determine the proper methods of exposure assessment for medical studies (Fig.3).

Materials and Methods

Workers. For the present study, a total of 76 men aged 35-60 years, 38 working at three military Radio Transmitting Centres (RTC) (10 – 30 MHz transmitters with .... kW power outputs) and 38 at two radio line stations was selected. All subjects were employed in 4-day working cycles with 12-h shift (day), followed by 24-h rest, 12-h shift (night) and 48-h rest. There were counted 125 shifts per year as the basis for calculation of cumulated life EMFs exposure dose. Characteristic of the groups of workers (size, age, working cycle, RF exposures) are summarized in Table 1. Thirty eight subjects were considered as exposed to RFs (at maximal values for E-field intensity during working shift showing individual differences from 9 to 174 V/m), while the remaining 38 did not experience measurable exposures.

Both these group (RF-exposed and non-exposed) were matched for age, duration of employment (6 – 34 years), nutritional state and health status at $p < 0.01$.

Measurement of RF EMF exposures. For measurements of electric (E) and magnetic (H) field strengths two different types of broad-band meters were applied:

1. MEH-25 meter (Institute of Microwave Technology, Technical University School, Wroclaw, Poland), equipped with:
   a) AE-1 electric field probe (100 kHz-300 MHz) with accuracy ± 10% in the range of 2-1000 V/m of electric field strength;
   b) Isotropic 3AE-2e electric field probe (100 kHz-300 MHz) with accuracy ± 10% in the range of 0.5-50 V/m of electric field strength;
   c) AH-1 magnetic field probe (100 kHz-300 MHz) with accuracy ± 10% in the range of 0.5-250 A/m of magnetic field strength.
2. The Wandol & Golterman Radiation Meter EMR-300 (Germany), equipped with:
   a) H field probe type 10 with accuracy of ± 0.5 dB over the range of 0.03 – 16 A/m and in the range of frequency of 27 – 300 MHz. In the range of 5 – 27 MHz a calibration coefficient was individually declared for measurements for each frequency individually;
   b) E field probe type 8 with accuracy of ± 0.5 dB over the range of 1-800 V/m for the range of frequencies 100 kHz-3 GHz.

Table I.
Dysregulation of autonomic control of cardiac function in workers exposed to 1-30 MHz RF radiation
Design of the study.

Groups of workers		
	Unexposed controls	**Exposed 10 – 30 MHz**
Number of subjects	**38**	**38**
Age	**44.8 ± 8.7**	**45.7 ± 8.9**
Working cycle	**4-day, 2 x 12 hr shifts**	**4-day, 2 x 12 hr shifts**
Exposure assessment		
E_{max} (V/m)	**0**	**109.7 ± 46.8**
E_{av} (V/m)	**0**	**6.0 ± 3.1**
D_{SF} $(V/m)^2$ x hr	**0**	**1088.1 ± 937.1**
D_L 10^4 $(V/m)^2$ x hr	**0**	**108.2 ± 81.3**
Cardiologic examinations		
• Routine medical examination • Questionnairing (risk of cardiac diseases) • Routine ECG at rest (10-min recording) • HRV (heart rate variability from 10-min ECG recording) • Holter 24-hr ECG recording • 24-hr ABP (ambulatory blood pressure)		
Analysis of results		
• Correlation of cardiologic examinations with RF exposure levels • HRV parameters (fast and slow components of the spectrum) in RF-exposed workers • ECG abnormalities in RF-exposed workers • Day/night ratio of BP and HR • Diurnal rhythms of BP and HR		

Protocol of investigations. The investigations planned for this study comprised questionnairing oriented toward risks of cardiac symptoms, general medical examination, ECG recording at rest, 24-h Holter ECG recording and 24-h ABP (ambulatory blood pressure) recording. From these recordings several parameters were computerised, including heart rate variability (HRV), number of ECG abnormalities, day/night BP and HR, as well as parameters of diurnal rhythms of BP and HR (mean value, amplitude and acrophase of the cosinor). The intendent procedures had to be properly coordinated with the 4-day working cycle of study workers in order not to interfere with direct RF exposure. The 24-tests were performed only during the 4th day of the working cycle, starting at 8:00 a.m (Table 2). This ensured at least a 1-day rest after each last working shift before the tests and provided relatively ordinary life conditions during testing. In the case of ABP recording, all subjects were instructed to rest (sleep) in bed without any physical or mentalactivities from 10:30 p.m. to 6:30 a.m. before during the day of test.

Methods of investigations

Medical examinations. Evaluation of the health status of workers was performed by extended questionaire completed by all investigated subjects. This questionaire (constructed at the Department of Work Physiology and Department of Epidemiology, Institute of Occupational Medicine, Lodz, Poland) contained particular questions regarding the type of occupation, stress of at work, course of work shifts, life and nutritional habits, physical activity, self-evaluation of health status and family history of metabolic and circulatory diseases. Response to the questionaire was followed by anamnesis and routine physical examination performed by qualified physicans from the occupational medical staff.

ECG recording at rest. Routine ECG recordings were performed during rest in the supine position from typical leads (precordial and extremities) using the Medea system[1].

Holter ECG recording. Twenty-four-hour ECG recording (starting at 8:00 a.m. on the 4th day of the working cycle) was performed using Medilog type 3000 (Oxford, England) and Crypton 2500 (Micro-Medics, France) sets from two bipolar leads CM5

and CS1. Final results included evaluation of basic parameters of the ECG curve (heart rate, R-R period, symptoms of mild ischemia or arrythmia).

Heart Rate Variability (HRV) using Medea-HRV. At least 600 heart cycles were registered to enable HRV analysis from 512 consecutive ECG cycles (R-R periods). HRV analysis included time-related parameters: duration of R-R periods (msec.), individual standard deviation of 512 R-R periods (msec.), median and modal values of R-R, as well as parameters of frequency spectrum distribution (FSD). For analysis of FSD a fast Fourier transformation (FFT) was applied. Low frequency (LF = L1+L2 = 0.04 – 0.15 Hz), known also as Mayer wave sinus arrythmia (MWSA), and high frequency (HF = F3 = 0.15 – 0.35 Hz), known as respiratory sinus arrtythmia, components of the spectrum were differentiated and computed for each individual.

Ambulatory Blood Pressure (ABP) recording. Oscillometric 24-h ABP recording was performed using Medilog (Oxford,England) [2, 10]. Automatic measurements of arterial BP were taken every 0.5 h during the day (6:00 a.m. - 10:00 p.m.) and every 1 h during the night (11:00 p.m. - 5:00 a.m.) for a total of 41 tests over 24 h. Systolic (SBP), diastolic (DBP), mean (MBP = SBP + DBP) blood pressure and heart rate (HR) were recorded in each test and used for calculation of diurnal rhytms. Recordings of ABP started at the same time of day (7:00 a.m.) in all studied subjects, but the first two recordings were deleted from analysis to allow adaptation to ABP recording.

Analysis of diurnal rhythms of blood pressure and heart rate. Diurnal rhythms were calculated for each individual by a least-square fit of a 24-h cosinor (Single Cosinor analysis) [4, 12, 14], the rhythm parameters (mean value, amplitude,acrophase) were taken from the sine curve equation and used for further analysis. A total of 2-3 missing values per 24 h ABP (41 recordings) were accepted for analysis of rhythms. All recordings were checked for artifacts, beside those automatically edited by the Medilog ABP monitor. Recordings which showed a differences > 0.5 of diurnal acrophase value between two adjoining records were considered as erromeus and/or perturbed by external stimuli (e.g. excitation). Such recordings were excluded from analysis by the computer program and parameters of the rhythm were recalculated to receive final values.

Results

Assessment of RF exposure. Deatiled results of monitoring of RF exposure during 12-hr shifts in all investigated RTC workers are summarized in Table II. Analysis of data indicate that there exist large individual differences in exposure levels (Emax ranging from 9 to 174 V/m, Eav for the shift from 0.5 to 11.4 V/m) (Table II), while time of real exposure (Tex) in measurable RF fields during the 12-hr shift appeared to be relatively short and lasted from 0.3 hr (18 min.) to 2.6 hr (2 hr 36 min) with mean value of 1.72 hr (1 hr 43 min).

A comparison of maximal exposure levels (Emax) and daily exposure doses (Dsf) (for calculations see Table II) for all investigated subjects revealed a high correlation between the two parameters (Prearson's coefficient $r = 0.876$). Additionally, 4 subgroups of workers, which differ considerably in levels of their RF exposure can be easily identified in the present population.

Changes in ECG and Holter recordings. Abnormalities and pathological changes in ECG recordings for workers at RTC radio link stations occured quite frequently both RF-exposed and non-exposed subjects (Table III). In the whole population (exposed and non-exposed) about 60% of ECG recordings (either resting or Holter ECG) have shown more or less easily detectable deviations diagnosed as conduction, rhythm or repolarization disturbances (Table III). In general, abnormalities and pathological changes in ECG recordings were found more frequently in RF-exposed group than in non-exposed workers (28 abnormal records in RF-exposed and 18 in non-exposed, $p < 0.01$), but in most cases the noted ECG abnormalities were listed as slight changes without clinical risks (e.g. number of extrasystoles slightly above normal levels, lowering of -ST fragment of the curve) (Table III). The most striking difference between RF-exposed and non-exposed workers was noted in the number of rhythm disturbances, including series of ventricular and supraventricular (atrial) extrasystoles (ExV, ExSV) (Table III). ExV and ExSV were detected in general from analysis of 24-h Holter ECG recordings and in most cases appeared to be short series of extrasystoles, amounting to a total of 100-400 ExV during the 24-h period recording, slightly above the upper limit accepted for healthy men of the respective age by an international group of experts [10].

Table II.
Assessment of individual exposure to 10 – 30 MHz radiofrequency fields in 38 workers of Radio Transmitting Centres (RTC), aged 45.9 ± 8.8 years, employed in a 4-day working cycle (12 hr work – 24 hr rest – 12 hr work – 48 hr rest).

Employment in RF fields (years)		Time of exposure during 12-hr shift (hr)		Total time of RF exposure per month (hr)		E_{max} (V/m) during 12-hr shift		E_{av} (V/m) during 12-hr shift		Dose (D_{SF}) during a 12-hr shift $(V/m)^2$ x hr		Life dose (D_{LF}) 10^4 $(V/m)^2$ x hr	
min.	2	min.	0.3	min.	11.2	min.	9	min.	0.5	min.	22	min.	1
max	34	max	2.6	max	82.3	max	174	max	11.4	max	3120	max	276
mean	21.02	mean	1.72	mean	53.24	mean	109.74	mean	5.98	mean	1088	mean	108.2
S.D.	9.68	S.D.	0.67	S.D.	20.84	S.D.	46.81	S.D.	3.13	S.D.	937.1	S.D.	81.3
Range	No. of subjects	Range	No. of subjects	Range	No. of subjects	Range	No. of subjects	Range	No. of subjects	Range	No. of subjects	Range	No. of subjects
< 10	3	0.3 – 1	9	10-20	8	< 10	1	< 2	8	< 100	8	< 5	8
10 - 15	8	1 – 1.5	0	21-40	1	10 – 50	4	2.1 – 6	10	100-500	2	6 – 50	5
16 - 20	6	1.5 – 2	11	41-60	12	51-100	11	6.1-8	5	501-1000	9	51 – 100	6
21 - 25	10	2 – 2.5	17	61-80	16	101-150	14	8.1-10	7	1001-2000	12	101 – 200	15
26 - 35	11	> 2.5	1	> 80	1	> 150	8	10.1-12	8	2001 - 3200	7	200 - 280	4

Table III.

Abnormalities and pathological changes in electrocardiographic (ECG) recordings in workers of Radio Transmitting Centres (RTC) exposed to 10-30 MHz RFs and in non-exposed workers of radio link stations.

	Whole population (N = 76)	RF-exposed workers (N = 38)	Nonexposed Controls (N = 38)	Statistical significance
Total number of workers with ECG abnormalities (standard and/or Holter)	**46** (61.0%)	**28** (74.0%)	**18** (47.0%)	$\chi^2 = 4.46$ $p < 0.05$
General Assessment of ECG recordins				
Normal (0)	**30**	**10**	**20**	$\chi^2 = 11.72$ $p < 0.01$
Slight abnormalities without clinical risks(1)	**30**	**18**	**12**	
Moderate disturbances, incl. lowering of –ST (2)	**12**	**7**	**5**	
Pathological changes with clinical risks (3)	**4**	**3**	**1**	
Predominant types of abnormalities and pathological changes In ECG recordings				
Conduction disturbances	**19**	**12**	**7**	$\chi^2 = 17.34$ $p < 0.01$
Intraventricular	5	3	2	
Intra-atrial	4	3	1	
RBBB	7	4	3	
Other	3	2	1	
Rhythm disturbances	**28**	**19**	**9**	
ExV	21	14	7	
ExSV				
Repolarization	7	5	2	
disturbances (incl. lowering of ST)	**16**	**10**	**6**	

NS – not significant (chi-square test, $p > 0.05$); **RBBB** – right bundle branch block; **ExV** – ventricular extrasystoles; **ExSV** – supraventricular extrasystoles; **-ST** – S-T fragment of the ECG recording.

Heart Rate Variability (HRV). Analysis of HRV, based on computation of 512 consecutive ECG cycles from resting recordings revealed significant lowering of low/high (FL/HF) component ratio (F1+F2/F3 and F2/F3) in RF-exposed subjects, compared to non-exposed controls ($p < 0.001$). The lowering of the low/high ratio resulted mainly from higher values of the respiratory sinus arrythmia (RSA) component of the frequency spectrum (0.15-0.35 Hz, expressed as F3), being an indicator of parasympathetic nervous system tonus. The F3 component of HRV spectrum has shown a significant negative correlation with RF exposure level of workers, expressed as the daily exposure dose (Dsf) ($F = 18.47$, $r = -0.447$, $p < 0.01$), similar to the negative correlation between Dsf and HRV slow/fast component ratio (Fig.6).

Analysis of ABP recordings. Analysis of 24-h ambulatory blood pressure recordings has shown that the average values of systolic and diastolic arterial BP for both investigated groups were within limits considered normal for healthy men (Table IV). High standard deviations (9 - 11 mmHg) indicate that exist indviduals with BP values exeeding upper limits of the normal range (Table IV). In fact, elevated values of BP during day, night and/or 24-h recording were found in six workers (16%) in the RF-exposed and in three subjects (8%) in the non-exposed group, but the difference was not significant. Systolic BP during the day was about 15 mmHg higher than during the night (Table IV). The day-night difference in diastolic BP reached 10-12 mmHg, and this resulted in BP day/night ratios of 1.10-1.20. The day/night ratios, both for BP and heart rate (HR), differed significantly between RF-exposed and non-exposed groups at $p<0.01$ (Table IV) and showed significant correlation with individual exposure levels (Dsf) .

Diurnal rhythms of BP and HR. In all investigated subjects the diurnal rhythms of BP and HR were well preserved and easily calculable (Fig.4).

The working in a 4-day cycle with alternate day and night 12-h shifts is not a normal situation and may lead to desynchronization of natural diurnal rhythms, e.g., in body temperature, heart rate, blood pressure, autonomic regulation and certain biochemical parameters [7, 13]. A typical result of desynchronization of these diurnal rhythms appears to be lowering of their amplitude, shifts of the acrophase (time of maximum) and changes in the time relation of dependent rhythms [5]. Analysis of systolic blood pressure values in healthy male (aged 35 years), between 0:00 and 9:00 p.m., revealed well preserved rhythm with two maxima during day-time and one minimum during night-time (Fig.8). The least-squeare fit of a 24-h cosinor (Single Cosinor analysis) flattens the maxima and minima and allows to calculate individual rhythm parameters - mean, amplitude and acrophase (Fig.4).

Table IV.

Analysis of 24-hr ambulatory blood pressure (ABP) recording and parameters of diurnal rhythms in workers exposed to 10-30 MHz RFs.

Parameter analyzed	Total population of workers (N = 76)	Exposed workers (N = 38)	Non-exposed workers (N = 38)	Statistical significance
SBP 24-hr (mean) (mm Hg)	130.4 ± 9.8	128.6 ± 10.4	132.4 ± 9.2	All differences NS P > 0.05
DBP 24-hr (mean) (mm Hg)	83.4 ± 8.8	84.6 ± 8.3	82.4 ± 9.1	
SBP day (mm Hg)	138.4 ± 10.7	137.4 ± 11.3	139.2 ± 10.3	
DBP day (mm Hg)	89.3 ± 7.8	88.4 ± 8.3	91.2 ± 7.6	
SBP night (mm Hg)	123.9 ± 7.7	123.5 ± 7.2	124.5 ± 8.3	
DBP night (mm Hg)	77.4 ± 6.8	78.6 ± 6.6	76.4 ± 7.1	
SBP day/night ratio	1.13 ± 0.06	1.11 ± 0.05	1.15 ± 0.06	P < 0.01
DBP day/night ratio	1.12 ± 0.05	1.09 ± 0.04	1.14 ± 0.05	P < 0.01
HR 24-hr mean	77.5 ± 7.2	78.4 ± 8.6	76.3 ± 6.6	NS
HR day	84.1 ± 8.4	83.5 ± 9.4	84.2 ± 8.2	NS
HR night	72.3 ± 6.4	74.2 ± 7.3	70.3 ± 5.4	NS
HR day/night ratio	1.15 ± 0.08	1.11 ± 0.07	1.18 ± 0.09	P < 0.01
Parameters of diurnal rhythms				
SYSTOLIC BLOOD PRESSURE				
24-hr mean value (mm Hg)	126.1 ± 7.1	126.5 ± 7.0	125.4 ± 7.2	NS
Amplitude (mm Hg)	15.4 ± 3.2	14.0 ±3.8	17.4 ± 2.6	P < 0.01
Acrophase (grades)	210.4 ± 22.7	199.6 ± 27.5	228.6 ± 20.1	P < 0.05
DIASTOLIC BLOOD PRESSURE				
24-hr mean value (mm Hg)	85.3 ± 4.9	84.6 ± 4.8	87.1 ± 5.1	NS
Amplitude (mm Hg)	11.4 ± 3.2	9.8 ± 3.6	12.3 ± 3.1	P < 0.01
Acrophase (grades)	205.4 ± 25.1	186.4 ± 28.4	231.3 ±23.5	P < 0.05
HEART RATE				
24-hr mean value	78.1 ± 8.1	77.3 ± 7.8	78.4 ± 8.8	NS
Amplitude	14.6 ± 6.4	11.4 ± 5.4	18.3 ± 7.2	P < 0.01
Acrophase (grades)	184.8 ± 23.6	168.3 ± 22.4	208.5 ± 24.2	P <0.05

SBP – systolic blood pressure; **DBP** – diastolic blood pressure; **HR** – heart rate.

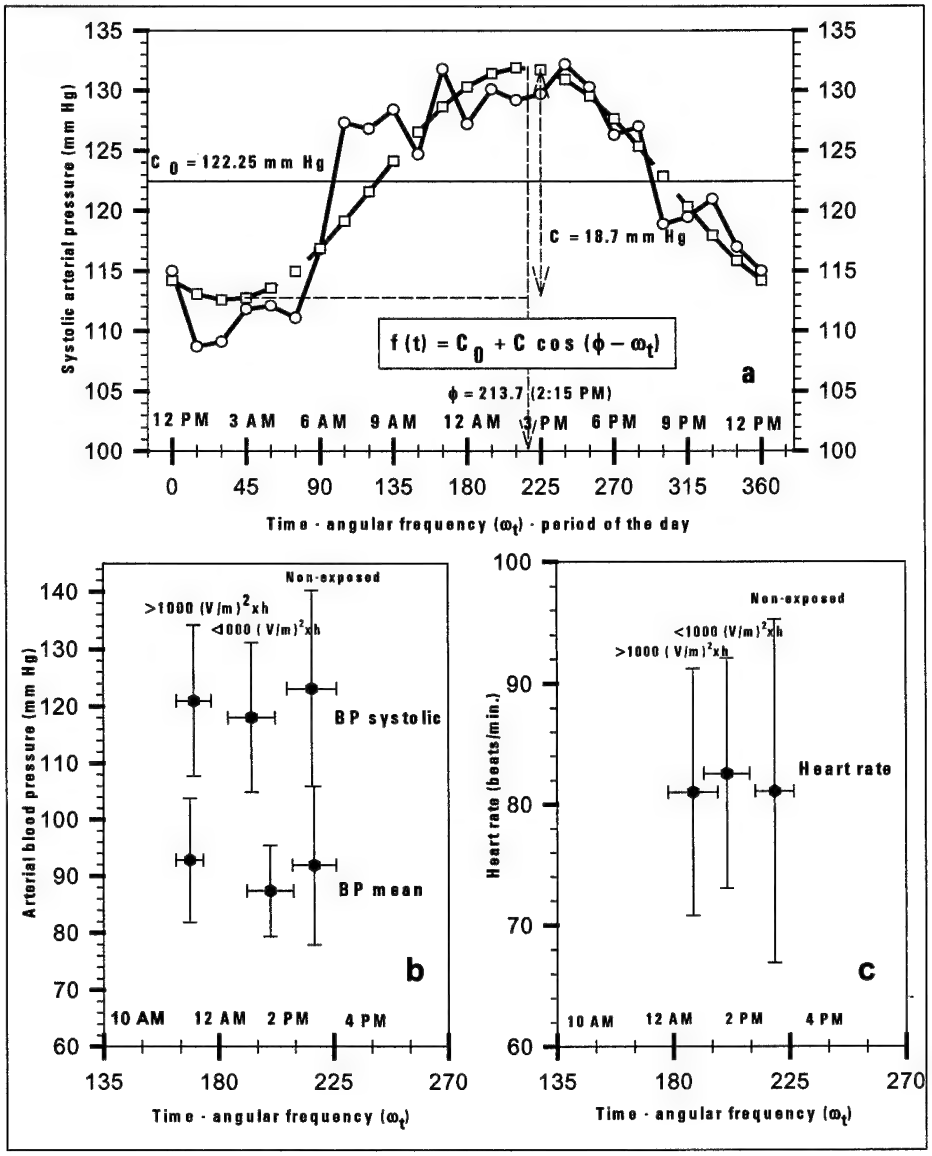

Figure 4.

Diurnal rhythm of systolic blood pressure in a 35-year old healthy worker not exposed to EM fields (a) and in the RF-exposed group of workers(b and c).

For unexposed workers the acrophase of all BP rhythms was about 220 ^{0} (3:00 p.m.) (Fig.4 b). In RF-exposed workers amplitude and acrophase of diurnal rhythms of BP differed significantly from values observed in unexposed subjects (Fig. 4b). Amplitude of rhythms was lower in the exposed and showed negative correlation with individual RF exposure dose (Dsf) (Fig.4). Acrophase of rhythms was shifted to about 180^0 - 195^0 (11:00 a.m. - 1:00 p.m.) and again, and showed negative correlation with individual RF exposure dose (Dsf).

The course of HR rhythms was in general similar to that of BP rhythms, but acrophase of the HR rhythms in both investigated groups were shifted to the left by about 30^0 (2 hr) and ranged from

165^0 to 210^0 (11:00 a.m. - 2:00 p.m.). Significant differences ($p < 0.01$) for amplitude and acrophase of HR rhythms were noted between RF-exposed and non-exposed groups (fig.4 b,c)

Discussion

In the present study, workers at radio transmitting centres (RTC) and radio line stations were diagnosed from the point of view of presence of functional disturbances of the circulatory system and increased risk for development of ischemic heart syndroms. All investigated subjects were qualified by occupational medical services as a fit for work at permissible intensities of RF EMFs.

The main results of our experiments revealed that there existed two types of changes in the investigated subjects. First, quite frequently in the EM-exposed workers there appeared various subclinical abnormalities in ECG recordings. Second type of changes was desynchronozation of diurnal rhythms of ABP and HR. The diurnal rhythm of BP is a major source of BP variability. ABP recorded in EM-exposed workers has shown repeatedly the liability of both SBP and DBP, being closely related to the activity of the subject [2]. The fall of BP at the rest time and a rise at the time of activity appears to be the most marked and persistent changes over the 24-h ABP [2]. Some authors conclude that the oscillations in the autonomic drive directed to the heart may be important in genesis of diurnal rhythms of cardiac function [5, 13]. In fact, day-to-night oscillations of sypathetic and parasympathetic nervous system activity were observed by spectral analysis of HR and BP [7]. Generally, different experimental dates indicate that diurnal rhythms of cardiovascular activity have their origin in the central nervous system [4,5,7].

Analysis of ECG recordings, received during our studies, points a variety of minor and more serious abnormalities and even pathological changes appearing quite frequently in both groups of workers. Close to 75% of RF-exposed workers showed various disturbances in condustivity, rhythm or repolarization, but in most cases only slight ECG abnormalities, without clinical relevance and risks have been identified. In fact, all types of abnormalities and pathological changes in ECG appeared more frequently in RF-exposed workers than non-exposed group ($p < 0.01$), but no particular form of ECG abnormalities could be identified as responsible for the difference between exposed and non-exposed subjects. Therefore, we cannot draw firm conclusion about higher risk of functional cardiac disturbances related to occupational exposure to RF. We cannot point the predominating types of these disturbances, which could be determined in the exposed group, too. Nevertheless, there exists a clear tendency for a higher number of mild rhythm disturbances (mostly small series of atrial extrasystoles, amounting to a total of 100-400 ExV during 24-h Holter recording) in RF-exposed workers. This tendency may be explained as the result of the functional

dominance of the sympathetic system in autonomic regulation of cardiac function in multiyear employees exposed to RF. On the other side, other results obtained in the present study do not confirm the presence of sympathicotonic regulation of cardiac function in RF-exposed workers. Particulary, no convincing symptoms for predomination of sympathicotonic regulation were found in analysis of HRV, including parameters of ECG frequency spectrum distribution,being considered as an objective method for evaluation of sympathetic-parasympathetic components in neurovegetative regulation of cardiac function [1, 2].

Statistically significant changes, between RF-exposed and non-exposed group, were found for their diurnal rhythms of BP and HR. A group of RF-exposed workers has shown considerable shifts in their diurnal rhythms of BP and HR. Mean 24-h values for systolic blood pressure (SBP),diastolic blood pressure (DBP), mean blood pressure (MBP) and HR did not differ from those recorded in non-exposed subjects employed at the same working pattern, but the day/night ratios and amplitude of the most rhythms were significantly lower. Additionaly, the acrophase of the rhythm was shifted to earlier hours of the day. Analysis of individual amplitude and acrophase values revealed their strong negative correlation with maximal RF exposure levels experienced during working shift. In view of these results it may be concluded that multiyear occupational exposure in RF EMFs can desynchronize autonomic neurovegetative control of cardiovascular function.

RF-exposed and non-exposed workers were employed on the same working pattern (a 4-day cycle which included two 12-h working shifts and one of the four days in the cycle with reversed activity - night shift) and such working pattern was continued for the whole period of employment (6-34 years). Therefore, all investigated subjects should be considered as adapted to a particualr working environments, which may generate modified course of physiologic rhythms, including diurnal rhythms of BP and HR. Neverthless,the differences observed between RF-exposed and non-exposed subjects can be attributed to influence of EMFs. Both groups were matched with regard to age, duration of employment, nutrtional stage, health status, level of physical activity, quality of sleep and timing of the sleep-wake transition. A link between EMF exposure and change of diurnal rhythm of BP and HR is additionally confirmed by a strong correlation of amplitude or acrophase values with individual RF exposure levels.

At present we cannot offer a resonable explanation for mechanisms responsible for changes of diurnal rhythms of BP and HR in workers exposed to RF EMFs. There exist no sufficiencely direct evidences to confirm the hypothesis that observed desynchronization of autonomic regulation of cardiovascular functions is a result of EMF exposure. But in the available literature there exist experimental date indicating that exposure of animals in controlled microwave fields may result in

desynchronization of cicrcadian rhythms, which leads in turn to disturbances in the function of certain organs and systems [9]. These results were never confirmed in epidemiological and medical investigations of humans exposed to electromagnetic fields. Results of the presented study supports, for the first time, the possibility that occupational RF exposure may desynchronize diurnal rhythms of BP and HR, generated by day/night oscillations of autonomic regulation systems.

In conclusion, it is our strong feeling that occupational exposure to RF fields increases the risk of disregulation of autonomic control of cardiac function. Such dysregulation is manifested by changed ratio of high/low fractions of HRV, increased number of functional ECG abnormalities and lowered day/night ratio of BP and HR. Additionaly, shifts of diurnal rhythms of BP and HR (lowering of amplitude, earlier occurance of acrophase) confirm the tendency for dysregulation of the autonomic control. However, the clinical relevance of the RF-related dysregulation of autonomic control of cardiac function and its influence on the possible increase of risks of cardiovascular diseases is not known; further studies for assessment of this possibility are needed.

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EPIDEMIOLOGICAL STUDY OF THE EFFECT OF RADIOFREQUENCY RADIATION ON OPERATORS IN RADIO, TV AND RELAY STATIONS

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INTRODUCTION

A wide-spread set of communication systems exists in the country. A great part of it consists of radio and TV stations, radio relay and satellite stations. In the last years a lot of new transmitters and relay TV stations were built and their power were higher, aiming to cover the whole country with a high quality signal.

Beside the effective power of electromagnetic radiation (EMR) emitted by the antennae in the environment due to the space diagram of the aerials, undesired leakage is radiated by the antenna-feeder systems, caused by nonhomogeneity and production defects, harmonics, etc. This dissipated radiation has high values in the near (reactive) zone - near field, where the electromagnetic waves are not radiated.

Most of the work places of the staff operating the systems can be found in the near-field zone, also in the whole area around the irradiation system, especially in the antenna-field.

High values of exposure exist near the final cascades of the amplifiers, when setting up or repairs are carried out, in the antenna's field (around the irradiating antenna), near the feeders or antenna control board.

Tube systems used in recent times do not function any more, but at the same time a sharp raise in the number of private radio- and TV- stations has been observed, which use some of the existing transmitters as well as a newly installed ones.

The long-term service of emitting systems results in serious health problems for operating staff, charged with broadcasting. Health studies of workers from radio-, TV- and other communication systems have been carried out during the last 20 years in numerous countries. Generalized results from electromagnetic field (EMF) measurements in workrooms with similar emitting systems show that the communication systems have been equipped with ones of the most effective screening protective devices. However, when power characteristics of EMF outside workrooms (within antennae field) during special repairing and setting are concerned, the field strength can reach to 520 V/m near antennae, under the feeder lines or close to antennae commutators.[6,9]

Evidence from studies carried out in former Czechoslovakia during the 80s showed the power exposure from medium- and short-wave antennae to be above permissible levels for the working hours.[6,8]

The first preliminary study in Bulgaria on the health status of radio and TV-service operators have been carried out in 1970s, indicating a health risk for the transmitter service operators. [4].

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MATERIAL AND METHODS

This study was performed on radio broadcasting systems of short waves (SW), medium waves (MW) and long waves (LW), television (TV), radio relay stations (RRS), and on satellite systems. A total of 24 stations with 94 transmitters with their average powers and frequency ranges of radiation shown on Table 1 were studied. Electromagnetic field measurements at all constant and temporary workplaces, also in living rooms were made, as the total number and their distribution are also shown on Table 1.

Table 1. Number and distribution of measurements by transmitters with average powers and frequency ranges

GROUP	Frequency	Power, kW	Number				Total number of measurements
			Transmitters	Work-places	Amenity Premises	Antenna Field	
Group I			11 sites	188	39	154	1034
LW and MW	261÷1485 kHz	1 ÷ 500 kW	15				
SW	3.9 ÷26.1 MHz	50 ÷ 500 kW	21				
FM	66.5÷105.0 MHz	1 ÷ 10 kW	27				
Group II A			6 sites	92	17	25	201
Group II B			3 sites	37	15	38	193
FM - TV	175 ÷223 MHz	1 ÷ 10 kW	11				
UHF - TV	511 ÷ 727 MHz	1 ÷ 40 kW	11				
Group III			4 sites	18	4	5	39
RRS	175 ÷ 631 MHz	0.01÷0.1 kW	8				
satellite	11 GHz	10 W	1				
Total	-	-	**24 sites**	**335**	**75**	**222**	**1467**

The operating staff of studied sites was divided in three groups:

- I-st group (Group I): engineering - technical personnel - 24 hours shift operators ;
- II-nd group (Group II): engineering-technical personnel - 8 hours shift operators;
- III-rd group (Group III): other workers - managers, cookers, cleaners, policemen, drivers, layers, etc. A part of the personnel travels every day to the stations, others working in stations situated in areas above 1500 m altitude remains there for 7 to 12 days.

The measuring methods used are described in some of Bulgarian standards, regulations and recommendations. [2]

Table 2 shows the distribution of 332 studied subjects by age and length of service.

Table 2. Distribution of studied subjects by age and length of service.

Group / Shift	Number of persons	Age, years X±s.d.	Length of service, years X±s.d.
Group I	143	43.6±10.0	18.3±11.2
24 h shift	84		
8 h shift	25		
other staff (service)	24		
Group II	124	41.8±8.3	13.1± 8.9
24 h shift	73		
8 h shift	22		
other staff (service)	29		
Group II	65	43.1± 7.7	15.3 ± 8.8
24 h shift	40		
8 h shift	12		
other staff (service)	13		
Total	332	42.8± 9.0	15.8±10.1

The character of the communication systems' service work required the subjects to be divided additionally into subgroups according to various indicators. It has to be noted that the subjects of

Group II were divided into two subgroups of personnel surveying two types of TV-transmitters - situated up to 1000 m (Group IIA), and higher than 1500 m above the sea level (Group IIB). The operators from the Group IIA travel every day to the workplace, while those of the other group - IIB stay at the workplace for 7 to 12 days, being followed by long day-off periods (about 20-25 days).

There are 24-hours shifts (24 h shifts) and "normal" - 8-hours shifts (8 h shifts) for different operators and for the other personnel. Those operators working in 24 h shifts use regularly 3 days holiday after every shift. The shift work length of 24 or 8 hours depends on the obligations and staff. Connected with the time of exposure subjects were divided into 3 subgroups, as it was shown above: 24 h shift workers; 8 h workers; other (assisting) staff (service) (24 or 8 hours shifts depending on the type of the station - under or above 1500 m.

The following jobs were characterized for workers in 24 h and 8 h shifts: radio engineer, engineer (both with master degrees), mechanic, technician, fitter, sound-technician, radio technician, power engineer, electric fitter, electrician, electric technician, mast operator.

The subgroup "other staff" includes: stewards, cleaners, policemen, drivers, electric fitters, canteen managers, cookers and other assistant jobs, being not directly engaged in the transmitters service.

MEASUREMENT AND EXPOSURE ASSESSMENT

The measurements of the EMF exposures were made using the following equipment:

N F M - 1 (made in Germany):

- measuring values: E = 2 to 40 kV/m for f = 50 Hz
  - ⇒ E = 2 to 1500 V/m for f = 0.06-350 MHz
  - ⇒ H = 0.1 to 10 A/m for f = 0.06-10 MHz
- uncertainty: $\sigma = \pm 20$ %
- power supply: a battery 9 V
- probes - dipole and frame.

P O - 1 (made in former Soviet Union):

- frequency range: f = 300 MHz to 16.7 GHz
- dynamic ranges:
  - ⇒ S = 0.1 μW/cm² to 5 mW/cm² for f = 0.3 to 1.2 GHz;
  - ⇒ S = 1 μW/cm² to 50 mW/cm² for f = 1.2 to 1.8 GHz;
  - ⇒ S = 0.5 μW/cm² to 7.5 mW/cm² for f = 1.8 to 5.6 GHz;
  - ⇒ S = 1 μW/cm² to 1.5 mW/cm² for f = 5.6 to 16.7 GHz.
- uncertainty: ± 30 %.

The apparatuses measure the EMF values in a wide frequency range (non-selective method) so we had to use specific methods for exposure assessment, described below.

The measurements were made for typical constant and temporary work places: transmission's halls, in front of the transmitters, central desks and central control desks, central control rooms, in front of the final cascades of multipliers, near the antenna control boards, etc. All measurements were made on three levels above the ground (floor) - on the levels of head, chest and genitals of the operator, and the hygienic assessment was formed according to the maximum measured value.

On the antenna's field area we measured the field strength both under the feeder lines (feeders) at the same three levels, and along the roots of the antennas, at distances of 10 to 50 m depending on the area.

In living rooms only the maximum values of EMF measured have been taken for hygienic assessment.

All measurements were made while the transmitters worked at maximum power of radiation.

On the time of measurements the serving operators stayed on minimal distance of 5 to 10 meters behind the measurer.

The hygienic assessment was elaborated using the maximum permissible levels (MPL) according to the state standards (Table 3) [2]. In the cases of simultaneous exposure to EMF from

radio frequency (RF - f < 300 MHz) and microwave (f > 300 MHz) bands we did summing up of the calculated energetic values:

$$W = \sum_{i=1}^{n} E_i^2 . T_i + \sum_{j=1}^{m} S_j . T_j$$

where E_i , S_j are the measured values of EMF for the periods of time T_i and T_j, respectively which allows a hygienic assessment of the "worst case".

The hygienic assessment of the measured values of EMF in the living rooms was made according to Ordinance No:9 for exposure to the general population (Table 3). The measured values of EMF in living rooms were added to the common assessment for the energetic loading of the organisms of the workers for 24 hours.

Table 3. Maximum permissible levels (MPL) according to the Bulgarian standards.

STANDARD	FREQUENCY RANGE	E_{max}, V/m	H_{max}, A/m	S_{max}, µW/cm²	$W_E=E^2.T$, $(V/m)^2.h$	$W_H=H^2.T$, $(A/m)^2.h$	$W_S=S.T$, µW.h/cm²
BNS 14525-90	60 kHz - 3 MHz	500	50	-	20000	200	-
	3 MHz - 30MHz	200	50	-	3200	200	-
	30MHz-300 MHz	60	-	-	800	-	-
Ordinance No:9/1991	30 - 300 kHz	25	-	-	-	-	-
	0.3 - 3 MHz	15	-	-	-	-	-
	3 - 30 MHz	10	-	-	-	-	-
	30 - 300 MHz	3	-	-	-	-	-
	0.3 - 30 GHz	-	-	10	-	-	-
BNS 17137-90	300MHz -300GHz	-	-	1000	-	-	200

The real time of exposure was determined in the following ways:

a) calculating method - calculating of the real time of exposure [4,8]:

$$t = \frac{E_{norm} - E_{avg}}{E_{max} - E_{avg}}, \text{ min}$$

where E_{norm} is the maximum permissible value of E for t = 8h, E_{ave} is the average value of the measured field strengths, and E_{max} - the maximum measured intensity for the relevant working place.

This method was applied only for the normal (8-hours) shift.

b) "script or scenario" method - an expert method, based on repeated measurements and for long findings of the working process. It was applied for the three groups of personnel (those, working for 24 h in a shift, others working for 8 h - normal shift, and for the "other" workers) at all studied sites, namely radio stations, TV stations and radio relay stations.

c) calculating the maximum permissible time duration. The requirements of the Bulgarian National Standards (BNS) were used when determining the limits of the energetic loading of the organism. Maximum permissible time duration of every working place was calculated according to the average values of EMF by using the formulae:

$$T_{max} = \frac{W_E}{E^2}, \qquad T_{max} = \frac{W_H}{H^2}, \qquad T_{max} = \frac{W_S}{S}$$

where W_E , W_H and W_S are coming from Table 3.

d) numerical method for calculating SAR for the 3 groups of personnel and for the different length of the shifts.

The assessment of SAR (Specific Absorption Rate) is made on the basis of the following assumes:

1. There is an effective surface of the human being, situated in EMF, varying depending on the frequency of the falling wave - A_e. For frequencies above 300 MHz is shown in Table 4:

Table 4. An effective surface of the human being (A_e) situated in EMF, depending on the frequency of the falling wave.

Frequency, MHz	A_e, m^2
410	0.033…2.33
1120	0.098…0.997
2890	0.140…1.05
4800	0.368…1.88
9375	0.495…1.22.

2. At frequencies below 300 MHz for calculation of whole body SAR are used the final frequencies of the subranges 30 kHz…3 MHz (3 MHz), 3…30 MHz (30 MHz) и 30…300 MHz (300 MHz).
3. At the time of exposure the large axis of the human being is parallel to the falling electromagnetic energy, i.e. the receiving aperture is linearly equally "lighted".
4. The main quantity of energy (83%) is concentrated within the human body margins if it would be equal in surface to a flat silhouette.
5. The determined value of SAR concerns the whole frequency range under the frequency for which it is calculated.

The method for calculation of whole body SAR is the following:
The following known relation is used

$$|SAR| = \frac{\sigma_t}{2\rho_t}|E_t|^2$$

The values of E_t are calculated for the corresponding frequencies, effective areas at previously calculated values of the energetic load of the organism:

$$W_E = E^2.T \ [(V/m^2).h];$$
$$W_S = S.T \ [\mu W/cm^2.h].$$

The latter are calculated for body weight of 75 kg, and for the respective groups - broadcasting stations LW and MW (Group I); TV and UHV (Group II) and radio relay stations (Group III, control). The calculations are made for each of the three groups by shifts for each of the above mentioned groups of studied individuals: for 24 h shift, "normal" 8h shift and for "other" staff members, working also 8 hours a day, and it is also a control group.

The calculations for the respective subranges, in which the Bulgaria hygienic norms are limited, show the following values, also the calculated SAR values (Table 5).

Table 5. The calculations for the respective subranges, in which the Bulgaria hygienic norms are limited

GROUP	RELATIVE UNITS ABOVE THE LIMITS	W_E [$V^2m^{-2}.h$]; W_S [$mW.cm^{-2}.h$]	f [MHz]	SAR.t [$J.kg^{-1}$]
Ist - 24 h	3.58	71649.00*	0.03	0.0245
			3.00	244.5020
Ist - 8 h	0.78	15666.80	0.03	0.0053
			3.00	53.4630
Ist - 8 h; other personnel	0.16	572.20	0.03	0.000164
			0.03	1.952000
IInd - 24 h	0.70	4502.50**		15.365000
				1536.50
IInd - 24 h		231.20	30.00	78.900000
			68-71	406.050000
IInd - 24 h		19.20	68.00	33.700000
			88.00	1.300000
IInd - 24 h	0.70	19.20	88.00	1.300000
			300.00	14.900000
IInd - 24 h		78.00	300.00	0.458000
			410.00	0.855800
			470.00	0.006450
			1120.00	0.366200
IInd - 8 h	0.21	992.70	3.00	3.387000
			30.00	338.700000
IInd - 8 h	0.21	60.70	30.00	78.900000
			68-71	406.050000
IInd - 8 h		6.40	68.00	11.200000
			88.00	0.430000
			88.00	1.300000
			300.00	14.900000
IInd - 8 h		26.80	300.00	0.152600
			410.00	0.285200
IInd - 8 h	0.21	26.80	470.00	0.021500
			1120.00	0.122030
IInd - 8 h; other personnel	0.19	499.30	3.00	1.704000
			30.00	170.400000
		38.70	30.00	13.200000
			68-71	68.000000
		27.20	300.00	0.037600
		27.20	410.00	0.298400
			470.00	0.002249
			1120.00	0.127700
IIIrd - 24 h	0.10	19.20	300.00	0.112700
			410.00	0.210600
			470.00	0.015900
			1120.00	0.090130
IIIrd - 8 h	0.03	6.40	300.00	0.037600
			410.00	0.070200
			470.00	0.005290
			1120.00	0.030050
IIIrd - 8 h; other personnel	0	0.00	300.00	0
			410.00	0
			470.00	0
			1120.00	0

*,** - above the maximal permitted levels (MPEs)

*MPE is 20 000 $V^2m^{-2}.h$

** MPE is 3200 $V^2m^{-2}.h$

e) calculation of TWA (Time Weight Average) for every shift.

$$TWA = \frac{\sum_i E_i.t_i}{T},$$

where E_i is the measured value on the "i" workplace; t_i is the time duration of exposure on the same place, i = 1,...n; $T = \sum_{i=1}^{n} t_i$ = 8h, 24h.

DESIGN AND PROCEDURE OF THE STUDY

The three groups: radio broadcasting systems (Group I), TV stations located at altitude up to 1000 m (Group IIA) and above 1500 m (Group IIB), and radio relay stations (Group III) were formed based on the hypothesis for different electromagnetic exposure to the staff. Because of the same reason the staff was considered as working at 24 h shifts, operators at normal shifts (8 hours), and other personnel (service).

Two control groups have been determined for the two distributions. The first control group comprise the service staff group (drivers, electricians, cooks etc.) from the three groups - radio broadcasting stations, TV and relay stations because of the low electromagnetic radiation. The same considerations (low level of exposure) we applied when we determined the workers at relay stations (Group III) as a control group for comparison with the other two groups - radio and TV stations (Groups I and II). The duties of the control groups in different stations are similar with the duties of the others but with much lower electromagnetic exposure than the other two groups.

1. Occupational psychological studies

The general status and psychic health of the staff were assessed with questionnaires. The indicators were the number of psychosomatic complaints, different aspects of satisfaction with the work and life, psychic and physical exhaustion immediately after the shift. Psychosocial factors affecting the health status, such as rate and strain of work, family problems related to shift work, possibility for participation in decision making, attitude to labour and personal resources - strategies for dealing with difficulties and available social support were also analyzed [8].

2. Assessment of the general adaptation resources of the organism; assessment of the general functional status.

A numerical method for analysis of heart rate variability (AHRV) was applied, enabling assessment of the state of general functional reserves and disadaptation of the organism [3]. The authors adopt the decreased levels of functional reserves of the organism as an individual morbid unit called Desaptenia (DAN). The most essential feature of DAN is the permanent ergotropic tuning of the autonomic nervous system, i.e. prevalence of sympaticotonus at rest. The diagnostics of DAN via AHRV is by using personal computer (PC) on the base of ancient Chinese methods for assessment of health and morbid states by the pulse rate. The principal indices for assessment of DAN by AHRV are: homeostatic index (HI), amplitude of the mode (AMo), index of vegetative balance (IVB), classification indicator (CI). The authors standardize those indices, and their mean values are determined for healthy persons of different age groups and for groups with different diseases.

3. Study of the workers neurological status

This task comprised routine methods for single determination of neurovegetative status of the service staff, namely: anamnesis, objective status (mobility, reflexes, sensuousness, coordination), methods for examining the neurovegetative status of upper limbs, capillaroscopy, orthoclinostatic test, pulse rate, blood pressure.

4. Biochemical studies.

Thirty male operators exposed to radiofrequency (RF) elecrtomagnetic (EM) radiation, divided in two groups: I group - eighteen operators at broadcasting station, aged 44,1 ± 10, 9 years with average length of service 23,4 ± 11,6 years and II group - twelve operators at a satellite station (SS) for TV communications and space research, aged 42,6 ± 4,7 years with average length of service 19,2 ± 5,9 years were investigated. The investigated operators worked 24-hour shifts (8:00 am to 8:00 pm), followed by three days off. A control group of 12 operators, aged 41,4 ± 4,9 years with lenght of service 21,3 ± 4,7 years, with similar job task and the same shift system was investigated, too.

Urine samples for 11-OCS and catecholamine analysis were collected on three hour intervals during the 24-hour shift. The 11-OCS and catecholamines excretion rates were determined by fluoriphotometric mehtods in our adaptation [10,11].

The parameters of diurnal rhythm were calculated by single Cosinor analysis at $p<0,05$. One-way analysis of variance (ANOVA) was used to assess the effect of RF EM exposure on the total 24-hour excretion, parameters of diurnal rhythm and the time-of-day variations of the investigated variables.

RESULTS AND DISCUSSION

1. Results from occupational psychological studies

More than one-third of all studied individuals report increased number of psychosomatic complaints with Groups I and IIA provide the highest rate of values exceeding the critical (41%). There is a marked tendency of increased complaints at 24-hour shifts and the individuals from the I group (radio broadcasting stations) where the exposure (energetic loading of the organism) is the greatest. The 8-hour shift shows the most prominent differences depending on the site group: Group I reports the most numerous complaints and Group III - the least numerous. More than half of the workers consider their work as monotonous - a feature determining the development of unfavourable psychic states. The complaints are mainly provided by the staff at 24-hour shifts (58.7%). The particular groups show statistically significant differences ($P = 0.01$) for this indicator. The staff belonging to the I group considers the work as the most monotonous.

High strain at work is reported by 43.8% of the studied workers with significant differences between the groups, particularly among the 24-hour shift workers. Up to 44% of the studied persons evidence psychic and physical exhaustion after work, instability more than twice per month as well as permanent disturbances in falling to sleep.

The unfavorable effects of strain and working conditions are more prominent in technical staff with greater exposure than the service staff. These complaints at 24-hour shift mode are as an average with 10 - 12% more than in the other groups. The particular groups of sites as well as groups of staff differ significantly for the index "psychic exhaustion after work" ($p = 0.05$). A total of 46.6% of the staff of groups I and II complain of psychic exhaustion more than twice per month while only 38 % of the service staff of these sites report such complaints. Respectively, the general stress state provoking wish to leave work in the middle of the shift is more frequently encountered in those two groups.

The age explains up to 5% of the total variation of psychosomatic complaints, psychic and physical exhaustion after work, with systematic, though weak effect on their increase.

The anamnestic (questionnaire) data reveal the most frequent manifestation of headache in 45.9% of the individuals of the Group I, in 34.0% and 38.0% respectively for the subgroups of Group II and in 30.8% for the "control" Group III. The declared complaints of headache, disturbed sleep, irritability, uneasiness and irascibility characterize a neurasthenic (neurosis-like) complex of symptoms. It is outlined in Group I - 24-hour shifts (45.8% of the group) followed by Group II (26.0%) and Group III (21.5%). The differences between the 24-hour and normal shifts in each group, except Group III (low exposure) are statistically significant ($p < 0.05$).

2. Results from the study of general functional status of the organism

The compiled results from the comparison of the studied indices are presented in Table 6.

Table 6. Complied results from the comparison of the studied indices.

Index	Number	Mean value X ± s.d.	Standard error	P < 0.05 by groups
P_{syst}	220	139.7 ± 24.5	1.7	-
P_{diast}	220	90.2 ± 13.5	1.0	-
Pulse rate	218	82.8 ± 11.7	0.8	-
AMo	100	25.1 ± 9.3	0.9	IIA : IIB IIB : III
HI	100	1.2 ± 1.2	0.1	IIA : IIB IIB : III
IVB	99	0.7 ± 0.3	0.03	-
CI	100	42.3 ± 59.4	6.0	IIA : IIB IIB : III
SD	100	70.0 ± 11.0	1.1	-

The differences between Group II and Group III (TV stations and Radio relay stations - "control") are significant. The statistically significant differences in the HI, AMo and CI for subgroup IIA and subgroup IIB are yet a more important finding. Evidently here the altitude factor - difference in the altitudes of the two stations - plays a certain role. The service staff reveals significant differences in P_{syst}, CI and SD between the most exposed individuals (Group I) and Group III (control). The disadaptation process includes decreased pulse rate variability (more unfavourable values of CI and SD) and increased P_{syst}. This is an expression of tonic ergotropic adjustment of the organism in response to the more unfavourable values of energetic loading of the organism, as it is in Group I.

The correlation analysis of the indices of HRV reveals high correlation ratios in Group I - at high values of exposure and low in Group III, where the electromagnetic exposure is almost zero.

3. Results from studies on the neurological status

The objective neurological status shows particular functional disturbances in the parts for testing the reflex functions and sensuousness although the majority of the studied persons are of normal reaction type. Hypereflexia is found in 7.3% and hyporeflexia - in 4.4% of the individuals in Group I.

No pathology is found in the sensuousness sphere.

The capillaroscopic data for spasticoatonia (in 31.3% of the studied population) and thermographic changes - spastic curves for upper limbs in 12.2% of Group I and 1.89% of Group IIA orient the neurovegetological study to objectivisation of angiodystonic phenomena with mainly spastic character, typical for RF exposure effect on human organism.

Two syndromes are prevalent:

- neurosis-like (neurasthenic) mainly in Group I (47.8%), followed by Group IIB (45.8%) and Group IIA - 26.0% of the studied individuals;
- angiodystonic syndrome (vegetative-vascular) with generalised arterial hypertension, mainly in persons from Groups I and IIA with length of service more than 10 years in conditions of EMF. Statistically significant differences are revealed at comparison between Group I and Group III; also 24-hour shifts and normal shifts within Groups I and II.

4. Results from biochemical studies

The total 24-excretion of 11-OCS was highly significantly lower in broadcasting station operators (F=16.389, p=0.0004) in comparison with the control group (Table 7), while in satellite station ones was significantly higher (F=5.072, p=0.035). The changes in the total 24-hour excretion

of catecholamines did not reach significance with the both investigated groups, but a trend for lower 24-hour excretion of adrenaline with the broadcasting station operators was found.

Table 7. Total 24-hour excretion and Cosinor analysis variables of 11-OCS, adrenaline and noradrenaline in broadcasting station (BCS) and satellite station (SS) operators during 24-hour shifts

Indexes	Group	Total 24-h excretion (nmol/24h)	Mesor ± SD (nmol)	Amplitude ± SD (nmol)	Acrophase ± SD (hour, min)
11-OCS	I gr. - BCS operators	50.50 ± 8.68***	2.07 ± 0.77**	1.57 ± 0.78	5:38 ± 1:22
	II gr. - SS operators	98.02 ± 25.71*	4.01 ± 1.15[t]	1.32 ± 0.78[t]	11:08 ± 5:19[t]
	Control group	77.88 ± 17.25	3.24 ± 0.71	2.02 ± 1.15	7:03 ± 2:09
Adrenaline	I gr. - BCS operators	37.85 ± 11.77[t]	1.56 ± 0.51*	0.58 ± 0.28	9:51 ± 3:47
	II gr. - SS operators	39.05 ± 8.45	1.61 ± 0.37	0.67 ± 0.38	13:01 ± 6:07
	Control group	45.53 ± 14.41	1.88 ± 0.61	0.47 ± 0.23	12:19 ± 5:11
Noradre-naline	I gr. - BCS operators	158.57 ± 50.94	6.76 ± 2.34	2.01 ± 1.52*	10:46 ± 4:19
	II gr. - SS operators	186.61 ± 37.93	7.68 ± 1.60	2.59 ± 1.30***	15:05 ± 4:32
	Control group	165.01 ± 38.10	6.91 ± 1.59	0.89 ± 0.32	13:57 ± 3:15

[t] p < 0.1 * p < 0.05 ** p < 0.01 *** p < 0.001

The Cosinor analysis revealed disorders in the circadian rhythm of 11-OCS in 8 out of 18 broadcasting station operators, in 9 out of 12 satellite station operators, and in 3 out of 12 subjects in the control group. A significantly lower 11-OCS mesor (F=17.433, p=0.0003) with the broadcasting station operators and a trend for higher mesor (F=3.844, p=0.063), lower amplitude (F=3.413, p=0.078) and shift in the acrophase (F=3.782, p=0.065) with the satellite station ones were calculated. Significantly lower 11-OCS excretion rates were found in the broadcasting station operators during the 24-hour period. The satellite station operators showed lower morning 11-OCS values and higher excretion rates in the period 14:00 - 03:00, reaching maximum significance at 17:00 - 20:00.

The Cosinor analysis revealed disorders in the circadian rhythm of adrenaline and noradrenaline in 14 out of 18 broadcasting station operators, in 6 out of 12 in satellite station operators and 6 out of 12 in the control group. Significantly lower adrenaline mesor was calculated with the broadcasting station operators, as well as higher amplitude/mesor ratio (F=3.913, p=0.058) and mesor deviation (F=4.992, p=0.033). The latter two indices were significantly higher with the satellite station operators, too.

In both investigated groups broadcasting station operators and satellite station operators noradrenaline excretion rates showed significantly higher amplitude (F=4.719, p=0.041 and F=19.297, p=0.0002), amplitude/mesor ratio (F=7.656, p=0.01 and F=17.230, p=0.0004) and mesor deviation (F=24.370, p=0.0000) and F=17.230, p=0004). No significant differences in noradrenaline excretion rates in broadcasting station operators compared with the control group were found, while moderate increase in the satellite operators group was found between 11:00 - 23:00, reaching significance at 17:00 - 20:00.

5. Results from the study of the Morbidity with Temporary Disability (MTD).

This study revealed that 78.9% of the operators at radio and TV stations have diseases, predominantly related to the central and vegetative nervous system, the cardiovascular, assimilation and excretion systems. The diseases of the assimilation and endocrine systems can be associated also with the disturbed functions of CNS, particularly of the system hypothalamus-hypophysis-adrenal cortex.

The diseases of the cardiovascular system are prevailing - 21.9% of all studied health files report hypertension. The total morbidity rate from hypertension in the country in 1990 is:

- urban population: 62.84/1000 persons
- rural population: 48.90/1000 persons
- total: 58.23/1000 persons.

For comparison, at a population of 128 individuals from the I and II groups, the rate of persons with hypertension is 38.3% and, in spite of the small sample, it is quite indicative.

CONCLUSIONS

High values of exposure of radio stations service staff are established. This is particularly valid for older MW and SW transmitters and for workers at 24-h shifts. The occupational risk is high also for staff at 24-h shifts in TV stations at altitude more than 1500 meters. The activities performed in antenna fields and antenna commutators are associated with exposure to high intensity EMF.

The service staff in Group I, besides electromagnetic exposure is subjected to the effect of additional factors of the environment, potentiating the hazardous effect of the radiation - overheating microclimate in the warm period of the year in old MW and SW transmitters, as well as noise on the hygienic threshold.

Complaints associated with deeper psychological changes were found in 37% of the studied individuals, statistically significant for persons from Groups I and II in comparison with the control Group III. The general tendency is to increase complaints from Group III to Group I and mainly to 24-h shifts.

The sense of monotony is the most expressed in Group I at 24-h shifts (74%). It correlates with psychic health, satisfaction with life and personal competence of persons with psychosomatic complaints above the critical value. Again Group I shows the highest rate (24.8%) of persons willing to change their jobs.

Data for neuro-vegetative dysfunction are found in all three groups, being higher in Groups I and IIB, particularly marked for 24-h shifts. The deviations correspond to the length of service.

The results from the study of general functional state of the organism suggest disadaptation changes, distress and exhaustion of adaptation reserves in the individuals from Groups I and IIB, due to the high energetic loading of the organism and, possibly, in Group IIB, the altitude factor.

The considerable number of operators with disorders in the circadian rhythms of 11-OCS and catecholamines indicates disruption of the circadian rhythm of stress hormones by the both investigated occupational exposures to RF EM radiation - high energetic loading in broadcasting station operators and low-level exposure in satellite station operators.

Highly significant suppression of 11-OCS secretion was found with high energetic loading (broadcasting station operators), while with the low-lelel one (satellite station operators) pronounced stress reaction was observed with changes in the circadian rhythm of the hormone, expressed by higher mesor, lower amplitude and shift in the acrophase.

The disorders in the catecholamines circadian rhythms were more often with high energetic loading (broadcasting station operators), with a trend for lower total 24-hour adrenaline excretion and significantly lower mesor.

The effect of RF EM radiation on stress hormones in both investigated groups was considerable. High energetic loading evoked severe supression of corticosteroids and disorders in the circadian rhythms of adrenaline and noradrenaline. The low-level RF EM radiation was associated with pronounced stress reaction with disorders in the circadian rhythmicity of corticasteroids. These changes could lead to health implications in view of the endocrine, metabolic and haemodynamic effects of stress hormones.

The greatest correlation ratio between altered indices and energetic loading of the studied persons is revealed in Group I and the smallest - in Group III which confirms the grouping according to the preliminary hypothesis for the effect of the major working environment factor - electromagnetic radiation.

This study evidences high occupational risk for workers at radio, TV, radio relay and spatial stations related to the effects of EMF and some additional factors of the working environment and process: shifts, tension, fatigue, overheating microclimate in the warm period of the year. This study was the basis for elaboration and implementation of technical, administrative and other preventive measures for protection of workers health.

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Annex 2 (1) - Task 1

Requirements for review of papers for replication. Necessary parameters/criteria

Below a group of requirements is presented which should be applied to future papers and studies.

We shall make an attempt to present the requirements to the studies as sheets for the different characteristics – identified (groups of) elements and operations as well as warranties for their availability.

I. We have already got inquire into the similar case of status *quo ante articula* (maximal requirements). There we propose to check the required qualities by individual rejoinders forming an inventory in a line of descent, stating alleviations, thus the absence of certain requirements to be slightened, if the given paper with inadequately presented study contains unique or markedly extravagant results.

Referring to the discussed here new papers, all previously stated in the above mentioned study requirements are valid, only without the outlined alleviations. Here, this treatment widens with new conditions:

II. New conditions

1. Here, the inventory of rejoinders is substituted with groups of congruities in logical conjoints.

2. These congruities are searched for en bloc.

3. Simplification (shortening) of the inventory:

The study of SAR and dose through stages of the irradiation process from a issue (I/O) to the biological object, referred to as a target (Bt) with biological properties and the effects in the biological substrate (Bs) enables the realization of a formal analysis of this process by the scheme "analytical description of the sequentially treated parameters, from issue "I" to "Bt" and then – in the analysis of the data from where a deduction or synthesis of effect assessment is achieved aiming at hygienic estimation. Each stage is assigned a set of elements. The operations between them are replaced with the operations addition and multiplication between algebraic analogues of these elements. They are defined in an abstract (phase) space as points and discreet intervals. The simplest division of the elements of a function and an argument is through secularization of the indexes of the characteristic element which is assigned the given point of the phase space of the indexes in this point. The following realization of a limit transition enables the inclusion of the description of each stage in an analytical expression for mathematical description of quantities the relationship between which are expressed quantitatively. The direct sequence of this "complication" is the possibility to equalize a number of requirements for each stage of the experiment, data processing and objects monitoring, leading to the hygienic estimation.

III. Basic requirements to the protocol of the paper

1. The reproducibility and replicatibility of the design and results within the task they are servicing as:

To present the results through a quantity comparable (functional or in regression at least) with the basic metabolite rate (BMR), and particularly – via SAR with the measurements for the data being reduced to data obtained at one and the same distance to the object, determined only by the wave length and the biological target at equal configuration of electromagnetic "lightening".

2. To provide means and methodology for the control of quantitative and qualitative characteristics and criteria for availability and assessment of characteristic and parameter for the study en bloc; Bt and the falling (at Bt location) radiation – the occurring EMF as a sequence of it.

3. Metrological provision and processing of data for best quality assurance. Concerning any publication as an *articulo ipso facto*, we must be sure that the grade is guaranteed by low and achievable basic uncertainty for each result. Marking this quantity we have in mind the primary texts to which every method should conform literally.

4. The bases and ways of comparison, correlation with the mutual values and with those from other articles, standardization and normalizing must be clearly stated and quoted. The explicit statement of the basis for such procedures or at least a way of their verification is obligatory.

As to referring to the inferior limit of an expanded uncertainty,

$U = ku_c$,

in the ideal case we reach to a level of confidence of 95 to 97%. The realized statistics is always a finite string of data, so even at normal Gaussian distribution we approximate by a finite function. Besides that this can always lead to great deviations, above the values of dispersion – eruption, the finite functions theory provides the following possibilities:

A. Unilateral determination towards the probability of the distribution of the quantity:

a) at summing by the module of the average square error (mod σ)

$9\% < U = ku_c < 15\%$ where k is the coverage factor

b) at treating by mod (3σ)

$5.196\% < U < 8.66\%$

B. At determination of the whole interval of probability densities towards a given mod, $p(-3\sigma) \leq p \leq p(+3\sigma)$

$3.67\% < U < 6.124\%$.

For the rest should be evident that the respective standards are applied, e.g. ISO 30012-1:1999(E), ISO 14253-1,2:1998(E), etc.

After that the type of the study should be revealed:

5. Whether the study is an experiment when a situation is organized and actively realized, at which a given effect is searched for and is parameterized the studied system "source-space", in which an EMF or a trace of irradiation originates or

this is a scrutinizing study, i.e. collection of data from measurement in a *status quo* – sampling in an EMF, etc.

6. It is possible to have parallelly an experimental process and scrutinizing. Then it should be known which procedure is prevailing, which is the initial one, when and in what order they shift or are in parallel; the time of each shift. This is a casus that we would like to illustrate by a digest of our experience and together with that to show the upper limit for U:

Example: We have to work often at field polygons on repair and accordance rendering of units, blocks and modules and devices which generate in different frequency spectral bands and in different dynamic power ranges. Normally for the purpose of hygienic estimation we make the usual measurements in parallel (together) with medical specialists' work. At that time they take some individuals out of the polygon and we start determining the emission modes, geometric axes mutual orientation of the emitter and receiver devices, respectively worker's area depending on the working posture. The statistics requests this cycle to be repeated. Finally, particularly after assessment of non-stochastic deviations like those caused by the personal equation (function) of the exposed person performing measurements, and influence of other frequency emissions, it can cause convergence of U to the inherent dispersion of the device, obtained by calibration.

Another case is the hygienic assessment of a far distance air-traffic landing direction when the work in real conditions with a sum of standard relative deviations of the order of 33.54% to 41.83%. The measurement under each antenna with reading the polarization plane rotation, the multifold measurement with approach from at least 4 different directions to the selected point and the use of two measuring devices can bring the deviation practically to device averaged effective error. For example, the realization of this procedure with two devices, for instance, Raham 495 and PO-1 Medicus, enables a reduction to $24\% < U < 26.73\%$.

7. It can turn out that the article presents studies of the class in question, that are not dosimetric nevertheless supplies such information, conforming with the requirements under the existing literature.

The detailing of those requirements by second descending hierarchical level contains:

A. Referring to the object (Bt): whether the effect of the irradiance is irreversible destroying the structures from tissue level downwards or there is a possibility for recovery of structures and infrastructures.

B. Referring to the issue (I), Bt and measurement equipment (ME): whether the basic metabolite rate (BMR) is disturbed – thermal irradiation or it is simply affected – non-thermally; for both it is important to state whether the overall metabolism is affected and/or chemism, i.e. whether there is actinic effect of EMF at a given exposure; whether the exposure is yet weaker – athermic or practically independent of the exerted on Bt effective power (Peff) at frequencies falling in the so-called "windows". Other type of frequently evidenced impacts are those with cooperative effects (the brain tissue of mice is resonantly activated but as a whole we have strong disturbance of the metabolic and chemical balance), induction of currents at irradiation in the near field and effects from primary external irradiation and induced cascades by decreasing frequency. The expansion of this nomenclature is a matter of knowledge.

C. Referring to I, Bt and ME as receiving and transmitting systems: to which type of antennae and other end devices for EMF propagation (e.g. waveguides) and how technically and which type of EMF generation is realized in each component – I, Bt, ME.

D. Referring again to Bt: whether the impact is on the activity of the organism or on the activity of its elements, on its chemism (e.g. opioids like a grade brain production); on systems of functional nature (e.g. cardio-vascular); syndromes are manifested (e.g. asthenic syndrome of the autonomic nervous system), behavioral disorders, etc.

Together with this description relating to the homeostasis and EMF attributed to each component (I, Bt, ME), the description of EMF is required, which we could name "description by mutual local phasing of the electric and magnetic fields":

a) distance between receiver and transmitter in units wave length – near field, far field, Fresnel zone or near inductive zone;

b) to what extent in the area around Bt respectively ME has changes in the propagation trace of irradiance. There are changes imposing transition from treating propagations in free space to treating local electric and magnetic fields in a function of Poynting's vector ;

c) to what extent the sensitive probe terminal is parallelly Hertz vibrator and Helmholtz probe; to what extent ME and Bt similarly perturbate the falling radiation/EMF;

d) to what extent the irradiance is from a single frequency emission; how many and which are the different frequency bands and how SAR is calculated out of the solution of the mono-frequency task;

e) with ME, how the occurrence of effects described after Wiedemann-Franz Law, i.e. the influence of a RF field at particular radiant heating on the metal conductivity in ME, is read;

f) how the dose and exposure are introduced as associated quantities, as well as the inherent errors; multi-frequency task or reading of harmonica (obertone, undertone);

g) characteristics of the impulse fields;

h) irradiance duration time; characteristics and energy parameters of irradiance interrupted during the time of the current study;

i) background determinations: natural background – levels by energy in the frequency band or elsewhere (why such selection) in unavailable technogenic emissions; technogenic background; values for irremovable technogenic fields; levels by energy for the highest frequency, which can be determined by ME;

j) co-factors of chemical and physical nature and their parameters;

k) exposure type: direct actinic; leading off the energy by a waveguide; closed TEM-cell; long line; others, e.g. conjugated horns or other antennae;

l) description of an optimum curve path of a moving Bt and introduction of the sensitive terminal of a device to the point in EMF;

m) model of Bt by EMF with a view to selection and implementation of a statistical approach;

n) implemented measurement principle via a ME and its compatibility with the frequency and dynamic ranges.

More comprehensive detailization is possible as well. For the cases covered by our practice, comprising laboratory and field polygon measurements, EMF parameterization in operation halls and physiotherapeutic facilities and measurements at workplaces in plants, halls and transport units, ship basements, etc. we have compiled a list of requirements and descriptions of the conditions within and for the system "I – trace of irradiance-Bt/ME". They enable to reach via the reverse way to the synthesis of the most possible missing intelligence or to precisely identify the gaps.

Conclusion:

1. The proposed inventory is a flexible hierarchically organized test table via which we can develop and deepen the level of conformity with the requirements through introducing more details.

2. The actual knowledge level selects sufficiently comprehensively each study, if average effective power and SAR can be defined and to outline, together with the reasons, the deviations or distortions and contortions or false assessments of these quantities.

3. It is reasonable that the data base should have a central peak file and subordinate peripheral files. There should be also an algorithm for following up and enrichment (in descending order) of actual and new characteristics at description of the discussed studies; at each updating the peripheral files should be tested again with a view to a new selection – towards the center or towards the periphery.

Unfortunately, most of the literature is in Cyrillic alphabet, and that is the reason not to be enclosed here. On request, it could be sent additionally.

Ideal case of protocol/design of EMF effect study with a view to replication (maximal requirements)

Main requirement: The tests and results should be reproducible within the frames of the task they serve. The results and conclusions should be repeatable at improved control and improved criteria added for availability of a given characteristic as a result from the experiment on the object (target), and of the parameters of the experiment.

Criteria for such quality of the paper or other form of presentation of the study should be: sheets/menu and nomenclatures with mandatory characteristics and alternative available (groups of) elements and operations.

I. Type of study:

1. Experiment: active reporting, organization and control.

2. Observation: passive experiment - organized evidence of occurring and presence of the target in the field and (state of) the target.

3. Combinations of 1. and 2.

II. Type of physical/biophysical effect at irradiation:

1. Destructive

2. Restructive:

a) thermal – actinic, metabolic

b) non-thermal

- actinic
- metabolic
- informational
- compartment, orientational, rotational
- e^{-} - bonds and double layer
- labilizing and latentifying

c) "windows" (frequency and/or by intensity)

d) cooperative effects

e) changes/activation of the homeostasis of the biological subject or an impacted part of it (target) at exposure, as a receptor system (e.g. adsorber, absorber, monovibrator, dipole, inductor, waveguide with different entries – horn, others)

- activity as a whole
- nerve activity and conductivity
- opioids

- titanic activity
- syndromes
- behavioral
- cardiovascular and blood flow; lymph flow
- other details

f) paradox (from contemporary point of view) phenomena..

III. Protocol of the physical experiment – requirements for presentation

1. *Equality of the falling/dissipated energy* on the object/target. Here the particular parameters are the following:

a) impedance

b) surface current density

c) induced current(s)

d) exposure = ordered couple – function of the energy and time – current time of the experiment

e) dose (D)

$D = \frac{\partial}{\partial m} W$; D ⇒SA, [J/kg]

f) SAR

$SAR = \frac{\partial}{\partial t} \frac{\partial}{\partial m} W$; SAR, [W/kg]

g) energy parameter = weighed value as a function of energy at a given exposure, W_p.

Each such quantity could be expressed in SAR units or alternatively - W_p

- SAR [W/kg]
- W_p [V^2hm^{-2}]; [A^2hm^{-2}]; [Wm^{-2}]

For the transition to the alternative quality and for setting the conditions of energy evaluation the following parameters are to be listed individually or as a coefficient of similarity:

- impedance Z_{TEM} ($Z_{transition}$)
- $\left|Z_{TEM}^{vac}\right| = \sqrt{\frac{\mu_r'}{\varepsilon_r'}} \approx \mathrm{Re}\left(Z_{TEM}^{vac}\right) + R_{f=0}$,

where

* the index "vac" relates to the value of Z_{TEM} in vaccum;

* the index "r" relates to the medium where the irradiation penetrates to depth α_r^{-1}

which medium has complex dielectric permeability

$$\varepsilon_r^* = \varepsilon_r^' + j\varepsilon_r^"; \quad \begin{Bmatrix} \varepsilon_r^' = \varepsilon^' \varepsilon_0 \\ \varepsilon_r^" = \varepsilon^" \varepsilon_0 \end{Bmatrix}; \; \varepsilon_0 \equiv \varepsilon_{vac}$$

* μ' is the real part of the magnetic permeability, so that, for a propagating electric field with presentation by a sinus function at a frequency f, and the Helmholz's wave-propagation equation is complied, the group velocity v_{gr} and the phase velocity v_{ph} of the electric field propagation (in vacuum $v_{gr} \equiv c$) are corresponding to the following relationships in transition conditions:

$$\frac{|v_{ph}|}{|v_{gr}|} \geq \left|\frac{1}{Z_{TEM}}\right|; \; |v_{ph}| = \left|\frac{v_{gr}}{Z_{TEM}} + \ldots\ldots\right|$$

$$v_{gr} = 1 / \omega.\sqrt{\sigma\mu}; \; \begin{Bmatrix} \omega = \dfrac{2\pi c}{\lambda} \\ \sigma = Z^{-1} \\ c = \sqrt{\varepsilon_0 \mu_0} \end{Bmatrix}$$

$$\left|\frac{\vec{r}}{\vec{v}} f\right| \equiv 1$$

and $\vec{r}$ is a radius-vector of the reading out.

- wave number (scale factor) in which is set/interpolated or extrapolated the propagation of the radiation within the limits of two sequential frequencies
$$k = \frac{2\pi}{\lambda} \to 0$$
$$\frac{\lambda_{\max}}{\lambda_{\min}} \to \lambda >> 1$$

- the relationship between intensity and power at a given effective area and density of the energy flow (module of Poynting's vector in quasi-free space), i.e.
$$E = f(Z, |\vec{S}|, P, A_e)$$

at available athermal effect for

$$|\vec{S}_{eff}| \leq \frac{P_{at}}{A_e}, Wm^{-2}$$

and the effective area A_e is a functional of the wavelength of the falling radiation by the polarization parameter, so that the effect of surfaces on the falling flow could be neglected

$$|E_q| = \sqrt{\vec{Z}\vec{S}_{eff}} \sqrt{P_{Ae}[mW.cm^{-2}]} = \sqrt{\vec{Z}\vec{S}_{eff}} \sqrt{\vec{S}_{measured}}\, q$$

Here, q is a calibration coefficient.

2. *Sources and generators* of the fields (electric - EF, magnetic - MF, and electromagnetic -EMF)

a) generation type

b) number and types of simultaneous sources

c) generator(s) supply

- independent
- from a common point
- grounding
  * LF (f 50/60 Hz) grounding
  * HF - mono-channel (single frequency band $f \pm \Delta f$;
  * HF - multi-channel (at significant power in the near bands $\Delta(f \pm \Delta f)$);

d) place and type of the emission channel and its coordinates in the experimental system or towards the metric coordinates

- coordinates relative to the point of measurement
  *geometric
  *phase center
  *amplitude center
  *convergence point/effective convergence to a pre-set power)
  *other
- type of output
  *dipole
  *monovibrator
  *horn
  *waveguide
  *border waveguide
  *inducing surface – non-homogeneous asymmetric capacitor (generator, route, medium between the generator and the target, target)
- sparkling
- output to an effective resonant circuit; plasma configuration;
- maser output/pupil
- output/channel system
- nuclear microexplosion/laser(s) system
- others

3. Emission

a) energy flow with a given density;

b) energy density or energy density gradient;

c) emission mode

- primary (frequency f)
  * from a single/individual generator
  * from several generators
  * directly falling;
  * leading off/re-irradiating of energy at lower frequencies than the primary

- secondary
  * border (for quasi-free propagation) effects
  * reflected; induced fields

d) differentiability of the irradiation (lack of heterodynation and/or interferential min/max):

- independence by primary emissions;
- independence of mode's emissions.

4. System, connecting or containing a generator and subject with a target = route

- medium; characteristics of currents and potentials in it and along the borders:
  * initial data for the current experiment time
  * degree of invariability of the parameters in the process of subject irradiation
    - theoretical prerequisites
    - empirical check
- EMF flow; propagation parameters;
- validity of "far-field"–presumption along the entire route:
  * background
  * check and current (device) control.

5. Necessary working parameters for irradiation assessment:

a) exposure = ordered couple of the type (A,t) or (A^2,t):

- t – time (current); [t] = s;
- A – signal amplitude:
  * intensity of electric or magnetic field, E or H;
  * $A^2 \approx |\vec{S}|; [A^2] \approx Js^{-1}m^{-2}$

b) dose, D; [D] = Jkg^{-1} = value of the quantity presenting the energy impact at existing "dose-response" relationship, with linear/lineated part;

c) quantities, characterizing the (possible) absorbed energy at external irradiation with accounting for the frequency dependence of the parameter:

- SA; [SA] = Jkg^{-1};
- SAR; [SAR] = Wkg^{-1};
- u; [u] = Jm^{-3};
- $|\vec{S}|; [\vec{S}] = Wm^{-2}$;
- intensities E, H; [E] = Vm^{-1}; [H] = Am^{-1};
- magnetic flux density B; [B] = T; Gs
- complex (W_{imp}/P_{imp}; F, τ; Q/N; FF_{imp});
  * energy/power, released in a single impulse; [W_{imp}] = J/[/P_{imp}] = W;
  * duration of the impulse, τ; [τ] = s;
  * impulse frequency, f; [f] = Hz;
  * repetition frequency, F; [F] = Hz;
  * quality factor, Q; [Q] = 1
  * FF_{imp} = formfactor of the impulse, [FF_{imp}] = Js^{-2}/ws^{-2};
- current density, j; [j] = Am^{-2};
- total current, I; [I] = A;

- polarizability, π; $[\pi] = 1$;
- magnet polarity, Bi; $[Bi] = Am^{-3}$;
- others.

d) quantities, related to object (target) energetics:

- BMR (basic metabolite rate, but the contribution of respiration is excluded); $[BMR] = Wkg^{-1}$ for comparison of mammals in vivo;
- free energy of Helmholtz, F; [F] = J – towards the lower limit of observed effects;
- index of activity IA; $[IA] = Wkg^{-1}$;
- others;

e) other parameters.

6. Background determinations (environmental factors)

a) natural background = levels of energy at preset frequencies, objectively existing and unconditional;

b) technogenic background = the lowest levels of energy provided that at a certain distance there are operating technological sources at the study frequencies ($f \pm \Delta f$);

c) present irremovable fields at frequencies $fp \neq f \pm \Delta f$

- level of energy, Lj for the highest frequency, accessible for measurement;
- Lj for fp = 0;
- Lj for fp at an established process;
- Lj for fp in areas next to f: $fp = f \pm \Delta f + c_1 - c_2$.

7. Way of exposure of the target:

- continuous;
- impulse;
- saccade (with interruptions) with its respective characteristics;
- intermittent:
  * uniform/non-uniform intervals;
  * uniform interruptions/non-uniform;
  * determined/by law;
  * randomized/by rule.
- pulsations in certain limits above the background:
  * statistical law for limit changes;
  * rule for averaging by power;
  * increasing signal;
  * increasing signal with saturation;
  * decreasing signal;
  * decreasing signal with saturation (asymptotic behavior).

8. Method for determination of falling flows at external irradiation on a (biological) target (bt) and on control-measuring equipment:

a) flows identity:

- zero/differential principle;

- putting/introducing a probe or a whole measuring module at the place of bt;
- synchronous multi-channel;
  * multi-channel in a unified process;
  * at several points/one or more processes realized by one or more devices;
  - sequentially with selection of time intervals;

b) identification time

c) frequency control;

d) phase control and physical trajectory (of the part of the flow);

e) calibration of the method and equipment through additional procedures, such as:
- calorimetry;
- dosimetry;
- exponometry;
- densitometry.
-

9. Frequency characteristics of the task and its solution
a) single frequency (with or without significant obertones and undertones (OT and UT);

b) two-frequency task:
- by SA or SAR parameter;
- transition to W_p;
- synchronicity of the measurement;
- total energetic loading;
- harmonics (OT and UT) of f_1 and f_2; differentiability vs. bands overlapping;
- "windows" and resonance width;

c) multi-frequency task
- frequency pairs;
- single type of tissue (organ) of bt;
- whole body = complex of targets in depth.

10. Monitored parameters of the object with its target part (bt):
- subject to exposure;
- subject to changes at exposure;
- sham & control/double sham;
- before exposure;
- during exposure/how (?);
- after exposure;
- physical;
- chemical;
- control BMR and gas exchange
- biochemical, and in particular:
  * protein surveillance;

* lipids;
* lectines (compilation of pearlchain);
*by Krebbs' III cycle
*conformation-rotational on macromolecular level – transition through liver membranes;
* crysti & vesiculae;
* ex tempori experimentaea;
* sequences.

11. Outlined advantages and disadvantages of the available study in the aspect of the resolved task.

12. Referring the results to "human being" and attempt to assess human health risk:

- deposited energy;
- sensitivity;
- assessment for whole body/inversions;
- assessment by equivalent bt (subcorporea)
- co-factors.

Annex 2 (2) - Task 1

Ideal case of protocol/design of EMF effect study with a view to replication (maximal requirements)

Main requirement: The tests and results should be reproducible within the frames of the task they serve. The results and conclusions should be repeatable at improved control and improved criteria added for availability of a given characteristic as a result from the experiment on the object (target), and of the parameters of the experiment.

Criteria for such quality of the paper or other form of presentation of the study should be: sheets/menu and nomenclatures with mandatory characteristics and alternative available (groups of) elements and operations.

I. Type of study:

1. Experiment: active reporting, organization and control.

2. Observation: passive experiment - organized evidence of occurring and presence of the target in the field and (state of) the target.

3. Combinations of 1. and 2.

II. Type of physical/biophysical effect at irradiation:

1. Destructive

2. Restructive:

a) thermal – actinic, metabolic

b) non-thermal

- actinic
- metabolic
- informational
- compartment, orientational, rotational
- e^- - bonds and double layer
- labilizing and latentifying

c) "windows" (frequency and/or by intensity)

d) cooperative effects

e) changes/activation of the homeostasis of the biological subject or an impacted part of it (target) at exposure, as a receptor system (e.g. adsorber, absorber, monovibrator, dipole, inductor, waveguide with different entries – horn, others)

- activity as a whole
- nerve activity and conductivity

- opioids
- titanic activity
- syndromes
- behavioral
- cardiovascular and blood flow; lymph flow
- other details

f) paradox (from contemporary point of view) phenomena..

III. Protocol of the physical experiment – requirements for presentation

1. *Equality of the falling/dissipated energy* on the object/target. Here the particular parameters are the following:

a) impedance

b) surface current density

c) induced current(s)

d) exposure = ordered couple – function of the energy and time – current time of the experiment

e) dose (D)

$D = \frac{\partial}{\partial m} W$; D ⇒SA, [J/kg]

f) SAR

$SAR = \frac{\partial}{\partial t}\frac{\partial}{\partial m} W$; SAR, [W/kg]

g) energy parameter = weighed value as a function of energy at a given exposure, W_p.

Each such quantity could be expressed in SAR units or alternatively - W_p

- SAR [W/kg]
- W_p [V^2hm^{-2}]; [A^2hm^{-2}]; [Wm^{-2}]

For the transition to the alternative quality and for setting the conditions of energy evaluation the following parameters are to be listed individually or as a coefficient of similarity:

- impedance Z_{TEM} ($Z_{transition}$)
- $\left|Z_{TEM}^{vac}\right| = \sqrt{\frac{\mu_r^{'}}{\varepsilon_r^{'}}} \approx \mathrm{Re}\left(Z_{TEM}^{vac}\right) + R_{f=0}$,

where

* the index "vac" relates to the value of Z_{TEM} in vaccum;

* the index "r" relates to the medium where the irradiation penetrates to depth

α_r^{-1}

which medium has complex dielectric permeability

$$\varepsilon_r^* = \varepsilon_r^{'} + j\varepsilon_r^{''}; \quad \begin{Bmatrix} \varepsilon_r^{'} = \varepsilon^{'}\varepsilon_0 \\ \varepsilon_r^{''} = \varepsilon^{''}\varepsilon_0 \end{Bmatrix}; \ \varepsilon_0 \equiv \varepsilon_{vac}$$

* μ' is the real part of the magnetic permeability, so that, for a propagating electric field with presentation by a sinus function at a frequency f, and the Helmholz's wave-propagation equation is complied, the group velocity v_{gr} and the phase velocity v_{ph} of the electric field propagation (in vacuum $v_{gr} \equiv c$) are corresponding to the following relationships in transition conditions:

$$\frac{|v_{ph}|}{|v_{gr}|} \geq \left|\frac{1}{Z_{TEM}}\right|; \ |v_{ph}| = \left|\frac{v_{gr}}{Z_{TEM}} + ...\right|$$

$$v_{gr} = 1 \Big/ \omega.\sqrt{\sigma\mu}; \ \begin{Bmatrix} \omega = \dfrac{2\pi c}{\lambda} \\ \sigma = Z^{-1} \\ c = \sqrt{\varepsilon_0 \mu_0} \end{Bmatrix}$$

$$\left|\frac{\vec{r}}{\vec{v}} f\right| \equiv 1$$

and $\vec{r}$ is a radius-vector of the reading out.

- wave number (scale factor) in which is set/interpolated or extrapolated the propagation of the radiation within the limits of two sequential frequencies

$$k = \frac{2\pi}{\lambda} \to 0$$

$$\frac{\lambda_{max}}{\lambda_{min}} \to \lambda >> 1$$

- the relationship between intensity and power at a given effective area and density of the energy flow (module of Poynting's vector in quasi-free space), i.e.

$$E = f(Z, |\vec{S}|, P, A_e)$$

at available athermal effect for

$$|\vec{S}_{eff}| \leq \frac{P_{at}}{A_e}, Wm^{-2}$$

and the effective area A_e is a functional of the wavelength of the falling radiation by the polarization parameter, so that the effect of surfaces on the falling flow could be neglected

$$|E_q| = \sqrt{\vec{Z}\vec{S}_{eff}}\sqrt{P_{Ae}[mW.cm^{-2}]} = \sqrt{\vec{Z}\vec{S}_{eff}}\sqrt{\vec{S}_{measured}}\, q$$

Here, q is a calibration coefficient.

2. *Sources and generators* of the fields (electric - EF, magnetic - MF, and electromagnetic -EMF)

a) generation type

b) number and types of simultaneous sources

c) generator(s) supply
- independent
- from a common point
- grounding
  * LF (f 50/60 Hz) grounding
  * HF - mono-channel (single frequency band $f \pm \Delta f$;
  * HF - multi-channel (at significant power in the near bands $\Delta(f \pm \Delta f)$);

d) place and type of the emission channel and its coordinates in the experimental system or towards the metric coordinates
- coordinates relative to the point of measurement
  *geometric
  *phase center
  *amplitude center
  *convergence point/effective convergence to a pre-set power)
  *other
- type of output
  *dipole
  *monovibrator
  *horn
  *waveguide
  *border waveguide
  *inducing surface – non-homogeneous asymmetric capacitor (generator, route, medium between the generator and the target, target)
- sparkling
- output to an effective resonant circuit; plasma configuration;
- maser output/pupil
- output/channel system
- nuclear microexplosion/laser(s) system
- others

3. Emission
a) energy flow with a given density;

b) energy density or energy density gradient;

c) emission mode
- primary (frequency f)
  * from a single/individual generator
  * from several generators
  * directly falling;
  * leading off/re-irradiating of energy at lower frequencies than the primary
- secondary
  * border (for quasi-free propagation) effects

* reflected; induced fields

d) differentiability of the irradiation (lack of heterodynation and/or interferential min/max):

- independence by primary emissions;
- independence of mode's emissions.

4. System, connecting or containing a generator and subject with a target = route

- medium; characteristics of currents and potentials in it and along the borders:
  * initial data for the current experiment time
  * degree of invariability of the parameters in the process of subject irradiation
    - theoretical prerequisites
    - empirical check
- EMF flow; propagation parameters;
- validity of "far-field"–presumption along the entire route:
  * background
  * check and current (device) control.

5. Necessary working parameters for irradiation assessment:
a) exposure = ordered couple of the type (A,t) or (A^2,t):

- t – time (current); [t] = s;
- A – signal amplitude:
  * intensity of electric or magnetic field, E or H;
  * $A^2 \approx |\vec{S}|; [A^2] \approx Js^{-1}m^{-2}$

b) dose, D; [D] = Jkg^{-1} = value of the quantity presenting the energy impact at existing "dose-response" relationship, with linear/lineated part;

c) quantities, characterizing the (possible) absorbed energy at external irradiation with accounting for the frequency dependence of the parameter:

- SA; [SA] = Jkg^{-1};
- SAR; [SAR] = Wkg^{-1};
- u; [u] = Jm^{-3};
- $|\vec{S}|; [\vec{S}] = Wm^{-2}$;
- intensities E, H; [E] = Vm^{-1}; [H] = Am^{-1};
- magnetic flux density B; [B] = T; Gs
- complex (W_{imp}/P_{imp}; F, τ; Q/N; FF_{imp});
  * energy/power, released in a single impulse; [W_{imp}] = J/[/P_{imp}] = W;
  * duration of the impulse, τ; [τ] = s;
  * impulse frequency, f; [f] = Hz;
  * repetition frequency, F; [F] = Hz;
  * quality factor, Q; [Q] = 1
  * FF_{imp} = formfactor of the impulse, [FF_{imp}] = Js^{-2}/ws^{-2};
- current density, j; [j] = Am^{-2};
- total current, I; [I] = A;
- polarizability, π; [π] = 1;

- magnet polarity, Bi; [Bi] = Am^{-3};
- others.

d) quantities, related to object (target) energetics:

- BMR (basic metabolite rate, but the contribution of respiration is excluded); [BMR] = Wkg^{-1} for comparison of mammals in vivo;
- free energy of Helmholtz, F; [F] = J – towards the lower limit of observed effects;
- index of activity IA; [IA] = Wkg^{-1};
- others;

e) other parameters.

6. Background determinations (environmental factors)

a) natural background = levels of energy at preset frequencies, objectively existing and unconditional;

b) technogenic background = the lowest levels of energy provided that at a certain distance there are operating technological sources at the study frequencies ($f \pm \Delta f$);

c) present irremovable fields at frequencies $fp \neq f \pm \Delta f$

- level of energy, Lj for the highest frequency, accessible for measurement;
- Lj for fp = 0;
- Lj for fp at an established process;
- Lj for fp in areas next to f: $fp = f \pm \Delta f + c_1 - c_2$.

7. Way of exposure of the target:

- continuous;
- impulse;
- saccade (with interruptions) with its respective characteristics;
- intermittent:
  * uniform/nonuniform intervals;
  * uniform interruptions/nonunoform;
  * determined/by law;
  * randomized/by rule.
- pulsations in certain limits above the background:
  * statistical law for limit changes;
  * rule for averaging by power;
  * increasing signal;
  * increasing signal with saturation;
  * decreasing signal;
  * decreasing signal with saturation (asymptotic behavior).

8. Method for determination of falling flows at external irradiation on a (biological) target (bt) and on control-measuring equipment:

a) flows identity:

- zero/differential principle;
- putting/introducing a probe or a whole measuring module at the place of bt;
- synchronous multi-channel;

  * multi-channel in a unified process;
  * at several points/one or more processes realized by one or more devices;
  - sequentially with selection of time intervals;

b) identification time

c) frequency control;

d) phase control and physical trajectory (of the part of the flow);

e) calibration of the method and equipment through additional procedures, such as:

- calorimetry;
- dosimetry;
- exponometry;
- densitometry.
-

9. Frequency characteristics of the task and its solution

a) single frequency (with or without significant obertones and undertones (OT and UT);

b) two-frequency task:

- by SA or SAR parameter;
- transition to W_p;
- synchronicity of the measurement;
- total energetic loading;
- harmonics (OT and UT) of f_1 and f_2; differentiability vs. bands overlapping;
- "windows" and resonance width;

c) multi-frequency task

- frequency pairs;
- single type of tissue (organ) of bt;
- whole body = complex of targets in depth.

10. Monitored parameters of the object with its target part (bt):

- subject to exposure;
- subject to changes at exposure;
- sham & control/double sham;
- before exposure;
- during exposure/how (?);
- after exposure;
- physical;
- chemical;
- control BMR and gas exchange

- biochemical, and in particular:
  * protein surveillance;
  * lipids;
  * lectines (compilation of pearlchain);
  *by Krebbs' III cycle
  *conformation-rotational on macromolecular level – transition through liver membranes;
  * crysti & vesiculae;
  * ex tempori experimentaea;
  * sequences.

11. Outlined advantages and disadvantages of the available study in the aspect of the resolved task.

12. Referring the results to "human being" and attempt to assess human health risk:

- deposited energy;
- sensitivity;
- assessment for whole body/inversions;
- assessment by equivalent bt (subcorporea)
- co-factors.

Annex 3 - Task 1

Criteria for reviewing literature in the field of RFR standards development

Basic Criterion for the RFR Exposure

1. This criterion could be applied to old and new publications describing results from empirical investigations on biological effects of EMF for the purposes of establishing hygienic limits. It is very strong to use for old literature but it contents the minimum requirements for future publications.

The criterion is brought to the following unique assessment:

- *the paper contains/does not contain the "necessary minimal data set" describing the conditions and results of the performed study to a stage of repeatability of the same conditions and results.*

The criterion is designed to validate results from significant EMF studies as an information for development of hygienic limits thus enabling its use – input in a general access "Data base for safety limits and protection from EMF".

It is evident that the effectiveness and nature of the criterion are uniquely dependent on the contents of the necessary minimal data set. This minimal set relates to sufficient and correct description of the empirical study and particularly to the description of the:

- Used EMF source;
- Subject studied;
- "Source-subject" system in the particular environment;
- Method(s) for control (measurement) of EMF;
- EMF measurement devices;
- Monitored subject parameter (before and after exposure);
- Health risk assessment.

2. Description of the necessary minimal data set

2.1. **EMF source**

Source characteristics:

a) Carrying frequency of the emitted signal - f = ...[Hz];
b) Emission frequency band – Δf = ... [Hz];
c) Mean and/or maximal emission power – P_{AVG} = ...[W], P_{max}=....[W];
d) Operation mode:
   - ➢ Continuous
     - ❖ frequency modulation;
     - ❖ amplitude modulation;
     - ❖ phase or frequency modulation;
     - ❖ non-modulated signal.
   - ➢ Pulsed
     - ❖ impulse duration τ = ...[s];

- frequency of repeat f = ...[Hz];
- increase time t = ...[s]

e) emission diagrams:

- angle width (at level minus 3 dB, by power) of "horizontal" diagram - $\Delta\varphi$ = ...[°];
- angle width (-3dB) at "vertical diagram - $\Delta\theta$ = ... [°];
- direction of maximal emission;

f) direction to the maximal irradiation

- to the object (in lab conditions)

or

- azimuth angle φ = ...[°] or
- circular;
- vertical angle - θ = ... [°];

g) scanning mode

- "horizontal" range - $\Sigma\Delta\varphi$ = ...[°];
- "vertical range - $\Sigma\Delta\theta$ = ... [°];
- scanning period – T = ...[s].

2.2 **Subject of investigation**

Subject type:

a) Model of

- human
- laboratory animal
- plant

b) Model characteristics

- dimensions L x H x D - …[cm]
- absorption / diffraction ratio in the model entity for EMF with carrying f - ….%;

c) Group of individuals

- number of control (C) and experimental (E) group C = [n], E = [m];
- Laboratory animals, type, number
  - number of control (C) and experimental (E) group C = [n], E = [m];
- Tissues from …….
  - number of control (C) and experimental (E) group C = [n], E = [m];

2.3 **"Source-subject" system in a particular environment**

Description of:

a) particular environment –

- natural environment, season
- laboratory

b) "source-subject" system:

- horizontal plan of interposition
- vertical plan of interposition

c) the exposure zone:

- near field

- intermediate field
- far field

2.4. **Exposure parameters**

- duration of single exposure – Δt =.....[h];
- number of exposures – n = ….;
- interval between exposures - ΔT =…..[h];
- amplitude and/or power characteristics of exposure in cross section:
- just before subject - E_{AVG} = …[V/m], E_{max} = …[V/m], B_{AVG} = ...[T], H_{AVG} = …[A/m], B_{max} = ...[mG], H_{max} = …[A/m], and S_{AVG} = ….[$\mu W/cm^2$] and/or S_{max} =….[$\mu W/cm^2$];
- just behind the subject – E_{AVG} = …[V/m], E_{max} = …[V/m], B_{AVG} = ...[T], H_{AVG} = …[A/m] B_{max} = ...[T], H_{max} = …[A/m], and S_{AVG} = ….[$\mu W/cm^2$] and/or S_{max} =….[$\mu W/cm^2$];

2.5. **Methods for control of EMF**:

- frequency selective
- frequency non-selective method

2.6. **Devices for EMF measurement**

- Measuring device type ………..
- Device for measurement of:
  - electric component
  - magnetic component
  - power density

- Manufacturer and year of production…….

- measurement range – from … to …

- dynamic ranges………..
- frequency band Δf = ….[MHz];
- sensitivity - ……..

Annex 5 - Task 1

INFORMATION SYSTEM

CREATION OF THE DATABASE FOR COLLECTING AND ANALYZING OF INFORMATION IN THE AREA OF ELECTROMAGNETIC FIELD EFFECTS ON THE HUMAN HEALTH

(Data base management system-DBMS in the field of EMF effects analysis)

Using different measurements methods, user can obtain various kind of information from various objects and various methods of measurements. In his investigations the user obtains numerical data from different sources (different types of sources by type of emitting, with or without additional factors of the environment).

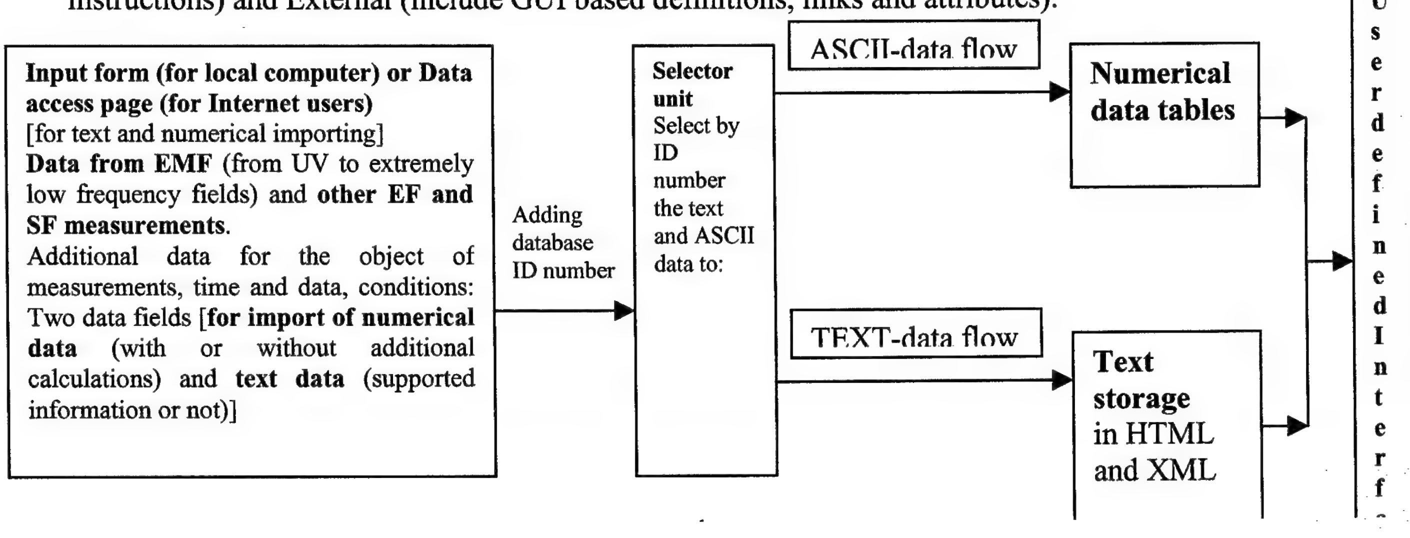
Through the database management system-**DBMS** user can be able to track information from a variety of sources that user has to coordinate and organize. User manages all of its information from a single database file. Within the file, the data is divided into separate storage containers - tables; view, add, and update table data by using online forms; to find and retrieve the data that the user wants by using queries; and to analyze or print data in a specific layout by using reports. It allows the users to view, update, or analyze the database's data from the Internet or an intranet by creating data access pages. Stored data in one table user can be used from multiple locations and when the user updates the data in this table it's automatically updated everywhere it appears. To store the data, the user can create one table for each type of information that has been track. To bring the data from multiple tables together in a query, form, report, or data access page, the user can define relationships between the tables.

To find and retrieve just the data that meets conditions that the user specifies, including data from multiple tables, should be created a query. A query can also update or delete multiple records at the same time, and performs predefined or custom calculations on our data.

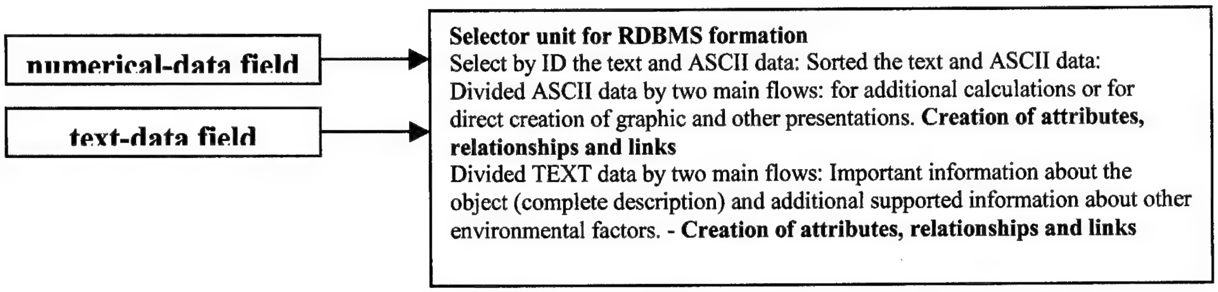
To easily view, enter, and change data directly in a table, create a form. When the user open a form, Microsoft Access retrieves the data from one or more tables, and displays it on the screen with the layout that user choose in the Form Wizard, or a layout that the user create from scratch.

To analyze user data or present it a certain way in print, create a report. For example, the user might print one report that groups data and calculates totals, and another report with different data formatted for printing mailing labels.

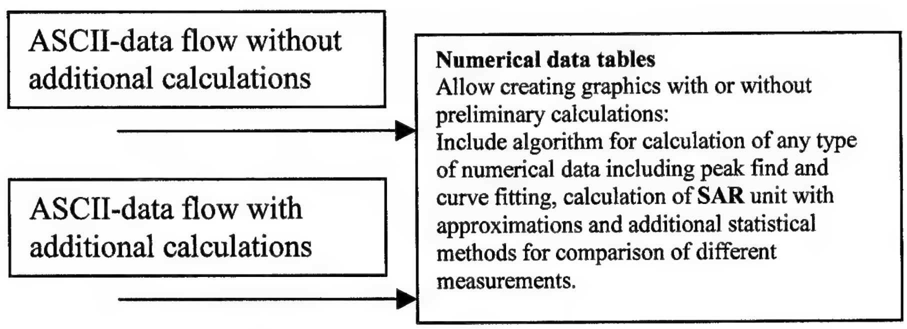
To make data available on the Internet or an intranet for interactive reporting, data entry, or data analysis, use a data access page. Microsoft Access retrieves the data from one or more tables and displays it on the screen with the layout that the user choose in the Page Wizard, or a layout that he create from scratch. Users can interact with the data by using features on the data access page.
There are existing two types of database structures: Internal (include program definitions and instructions) and External (include GUI based definitions, links and attributes).



External Structure of the database: ***Figure 1.1.***



External Structure of the database (**selector unit** for Relational Database Management System RDBMS formation): ***Figure 1.2.***



External Structure of the database (**Numerical data tables**): ***Figure 1.3.***

SF – static field
EF – electric field
EMF – electromagnetic field
HTML – hyper text markup language
XML – dynamic hyper text markup language

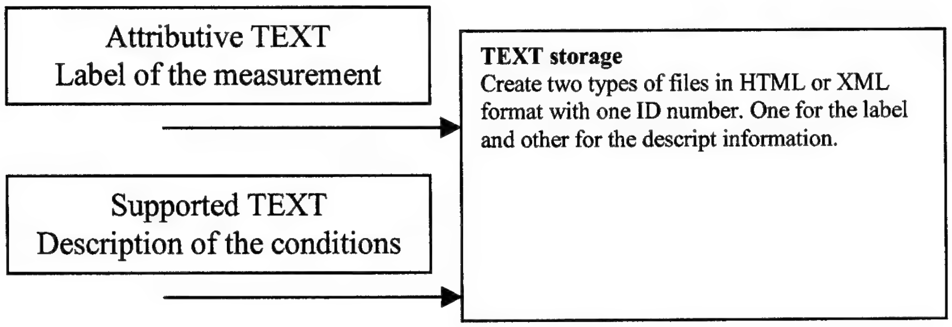
1.**About the numerical data tables:**

A table is a collection of data about a specific topic, such as values or time of measurements. Using a separate table for each topic means that the user stores that data only once, which makes our database more efficient, and reduces data-entry errors. Tables organize data into columns (called table fields) and rows (called table records). A common field relates two tables so that Microsoft Access can bring together the data from the two tables for viewing, editing, or printing. In table Design view, the user can create an entire table from scratch, or add, delete, or customize the fields in an existing table. In table Datasheet view, the user can add, edit, view, or otherwise work with the data in a table. He can also display records from tables that are related to the current table by displaying sub datasheets within the main datasheet. With some restrictions, the user can work with the data in sub datasheets in many of the same ways that he works with data in the main datasheet.

Operations with tables

2.**About the forms: How they work?** The user can use forms for a variety of purposes, Most of the information in a form comes from an underlying record source. Other information in the form is stored in the form's design. He can create the link between a form and its record source

by using graphical objects called "controls". The most common type of control used to display and enter data is a text box.



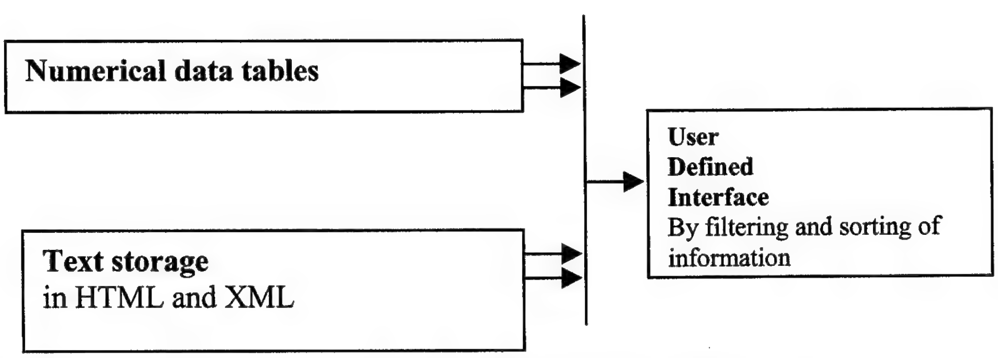
External Structure of the database (**TEXT storage**): ***Figure 1.4.***

3. **About reports (Obtained through User Defined Interface):**

By request of the user, database could generate different kind of reports. Through the filtering and specific searching in database, user can obtain requested information in the proper format.

A report is an effective way to present our data in a printed format. Because the user has control over the size and appearance of everything on a report, he can display the information in the way that he wants to see it. Most of the information in a report comes from an underlying table, query, or SQL statement, which is the source of the report's data. Other information in the report is stored in the report's design.

The user can create the link between a report and its record source by using graphical objects called "controls". Controls could be text boxes that display names and numbers, labels that display titles, or decorative lines that graphically organize the data and make the report more attractive.



External Structure of the database (**User Defined Interface**): ***Figure 1.5.***

4. **Data access pages**

4.1.Designing different types of data access pages

The user designs data access pages in page Design view in Microsoft Access. The page is a separate file that is stored outside Microsoft Access; however, when the user creates the file, Microsoft Access automatically adds a shortcut to the file in the Database window. Designing a data access page is similar to designing forms and reports — the user uses a field list, the toolbox, controls, the **Sorting and Grouping** dialog box, and so on. However, there are some significant

differences in the way that the user designs and interacts with data access pages as opposed to forms and reports. How you design the page depends on what it will be used for:

Interactive reporting This type of data access page is often used to consolidate and group information that is stored in the database, and then publish summaries of the data. For example, a page might publish the sales performance for each region in which user does work. Using expand indicators, user can go from a general summary of the information, such as a list of all the regions and their combined sales total, to specific details on individual sales within each region. While the data access page may also provide toolbar buttons for sorting and filtering the data, user can't edit data on this type of page. See an example and learn more about data access pages that group records for interactive reporting.

4.2. Data entry This type of data access page is used to view, add, and edit records. Learn more about data access pages used for data entry.

4.3. Data analysis This type of data access page may include a PivotTable list, similar to a Microsoft Access PivotTable form or Microsoft Excel PivotTable report, that lets user to reorganize the data to analyze it in different ways. The page might contain a chart that the user can use to analyze trends, to detect patterns, and to compare data in user's database. Or the page might contain a spreadsheet in which the user can enter and edit data, and use formulas to calculate as he does in Microsoft Excel. See an example of a data access page used for data analysis.

5.Using data access pages in Internet Explorer

A data access page is connected directly to a database. When users display the data access page in Microsoft Internet Explorer, they are viewing their own copy of the page. That means any filtering, sorting, and other changes they make to the way the data is displayed — including changes they make within a PivotTable list or spreadsheet — affect only their copy of the data access page. However, changes that they make to the data itself — such as modifying values, and adding or deleting data — are stored in the underlying database, and therefore are available to everyone viewing the data access page.

Users get Help on how to work with the page in Internet Explorer by clicking the **Help** button on the record navigation toolbar. The Help file that displays is automatically included with any data access page that's published with a record navigation toolbar. If the user deletes the record navigation toolbar or if he disables the **Help** button on it, he should provide instructions for those who will use the page.

Note To view and work with the data access page on the Internet or an intranet, users need Microsoft Internet Explorer 5 and a Microsoft Office 2000 license.

6.Using data access pages in Microsoft Access

User can also work with a data access page in Page view in Microsoft Access. Data access pages can supplement the forms and reports that he uses in itself database application. When deciding whether to design a data access page, form, or report, consider the tasks that he want to perform.

7. Internal structure- User defined interface through the Macros: What they are and how they work

What is a macro?

A macro is a set of one or more actions that each performs a particular operation, such as opening a form or printing a report. Macros can help user action to automate common tasks. For example, user can run a macro that prints a report when a user clicks a command button.

A macro can be one macro composed of a sequence of actions, or it can be a macro group. User can also use a conditional expression to determine whether in some cases an action will be carried out when a macro runs.

7.1. A sequence of actions

The following macro is composed of a series of actions. Microsoft Access carries out these actions each time the macro runs. To run this macro, user refers to the macro name Type of Measurements.

The name in the **Macro Name** column identifies each macro. When user run a macro in a macro group, Access carries out the action in the action column and any actions that immediately follow whose **Macro Name** column is blank.

To run a macro in a macro group, user uses the macro group name followed by a period and then the macro name. In the preceding example, to refer to the Eenvironmental factors macro in the Buttons macro group, you would type **Buttons. Environmental factors**.

7.2. Conditional actions

To display the **Condition** column, user clicks **Conditions** on the **View** menu in the Macro window. The following macro runs the MsgBox and the StopMacro actions only when the expression in the **Condition** column is true (when there is a **Null** value in the SupplierID field).

Contract Order Number F61775-01-WE022.
Prof. Michel Israel, Ph.D.

Report on Task 2. ***Developing of working groups from East Countries for involving them in an international standard harmonization process. Creating a database for such specialists for future collaboration.***

In our Interim Report we presented two databases of specialists working before and now in the field of RF human exposure. We completed the following activities to achieve the required result:

1. **Collecting an international working group for participating in the project. Database for specialists in standards development in East European countries (EECs) for future collaboration.**

The working group (WG) was collected by direct contacts with specialists involved in the standard development in several countries. These countries were the following:

- Bulgaria
- China
- Croatia
- Czech Republic
- Hungary
- Poland
- Romania
- Russia
- Serbia (Yugoslavia).

Additionally, we tried to involve in this working group specialists from countries in the Balkans, and from some West European Countries (WECs) to participate or to be consultants. These countries were:

- Germany
- Greece
- Italy
- Japan
- Turkey.

Why just these countries?

We chose Germany for two reasons: first, it is a country where many specialists have been involved in the eastern standard development process (East Germany), and second, as a country where ICNIRP philosophers are doing research now.

Choosing Greece and Turkey, we tried to involve all Balkan countries in the standard harmonization process.

Italy – because very low limits for RFR human exposure were accepted two years before.

Japan – because in this country there are specialists having big interest in the standard harmonization process worldwide, also because of our possibility to contact with the exact persons working in the field of the standard development.

Result/Deliverables No.1 and 3:

The result is that we developed an international working group including the following specialists:

Bulgaria: Michel Israel, Miltcho Vatsov, Michaela Ivanova, Veska Topalova, Stancho Enev, Krasimir Zhelev, Lubomir Traikov, Peter Chobanov, Plamen Tomov, Ivan Nedeltchev. Technical Assistants: Victoria Zaryabova, Rumiana Petrova, Magdalena Dimitrova, Lubomir Zarkov, Lubomir Dimitrov

China: Huai Chiang, Z J Cao, Z Q Zao

Croatia: Dina Simunic

Czech Republic: Ludek Pekarek

Hungary: Georgy Thuroczy

Poland: Halina Aniolczyk, Stanislaw Szmigielski

Russia: Yuri Grigoriev, Nina Rubtsova, Jouri Paltsev, Valentina Nikitina;

Serbia (Yugoslavia): Vesna Drincic

From the WECs:

Turkey: Nesrin Seyhan, Ayse Canseven

Japan: Chiogy Ohkubo

Consultants: Paolo Vechia (Italy), Jan Musil (Czech Republic).

We didn't receive any answer from Greece and Romania.

A list of the specialists working in the field of standard development, as an international working group from the EECs for future collaboration in the field of standard development is given above. This list is only the first step to create such a WG, and it could be enlarged in future.

2. **Developing of working group from EECs for involving them in the international standards harmonization process.**

To develop the WG for future participation in the standard harmonization process worldwide we attached several conditions to the persons who could be involved in Questionnaire, No.4). In our questionnaire there were the following requirements for every participant:

- To be open-minded;
- To be open to accept other ideas and open for discussion;
- Language skills (mainly English);
- Active working in the field of RFR exposure and risk assessment for standard development.

At this time, the following list of specialists is that one we have accepted as responding to the requirements:

Result: A regular working group of specialists from EECs for an international collaboration in the field of standards harmonization worldwide – **Annex 1 (Task 2).**

Bulgaria: Michel Israel, Peter Tchobanov, Michaela Ivanova

China: Huai Chiang, Z J Cao, Z Q Zao;

Croatia: Dina Simunic

Czech Republic: Ludek Pekarek

Hungary: Georgy Thuroczy, Laslo Szabo

Poland: Halina Aniolczyk, Stanislaw Szmigielki
Romania: no information
Russia: Youri Grigoriev, Nina Rubtsova, Jouri Paltsev, Valentina Nikitina;
Serbia (Yugoslavia): Vesna Drincic

From the WECs:
Turkey: Nesrin Seyhan, Ayse Canseven, Abdullah Rasit Gulhan
Consultants: Paolo Vechia (Italy), Jan Musil (Czech Republic).

Annex 1 - Task 2

Table 2. Working group of specialists from EECs for international collaboration in the field of standards harmonization worldwide.

Country	Specialists	Organization	Addresses
1	2	3	4
Bulgaria	Michel Israel	National center of Hygiene, Medical Ecology and Nutrition	15,D.Nestorov Str. 1431 Sofia, Bulgaria m.israel@nchmen.government.bg michel.israel@eudoramail.com
	Peter Chobanov	Military Medical Academy - Military Hygienic Epidemiological Inspection	
	Michaela Ivanova	National center of Hygiene, Medical Ecology and Nutrition	m.ivanova@nchnen.government.bg
China	Huai Chiang	Zhejiang University, School of Medicine	hch@mail.hz.zj.cn
	Z J Cao	Chinese Academy of Preventive Medicine	no address
	Z Q Zao	Beijing Medical University	no address
Croatia	Dina Simunic	University of Zagreb Faculty of Electrical Engineering and Computing	Unska 3 HR-10000 Zagreb CROATIA dsimunic@cedrus.cc.fer.hr
Czech Republic	Ludek Pekarek	Hygienicka Stanice Hlavniho Mesta Prahy	Rytirska 12 P.O.Box 203, 11001 Praha 1 Czech Republic opl@iol.cz
Hungary	Georgy Thuroczy	National Research Institute for Radiobiology and Radiohygiene	thuroczy@hp.osski.hu
Poland	Halina Aniolczyk	Nofer's Institute of Occupational Medicine, Lodz	8 Teresy Str. P.O.Box199 90-950 Lodz, Poland PZELMAG@IMP.LODZ.PL
	Stanislaw Szmigielski	Military Institute of Hygiene and Epidemiology, Warsaw	szmigielski@wihe.waw.pl
Romania	no information		
Russia	Nina Rubtsova	RAMS Institute of Occupational Health	Prosp. Budennogo,31 Moscow 105275 Russia rtv@ess.elektra.ru
	Valentina Nikitina	North-Western scientific center of Hygiene	4, 2nd Sovetkaya street, St. Petersbourg Russia vnn@spb.cityline
1	2	3	4

	Jouri Paltsev	RAMS Institute of Occupational Health	Prosp. Budennogo,31 Moscow 105275 Russia
	Youri Grigoriev	State Scientific Center, Institute of Biophysics	yurgrigor@cityline.ru
Turkey	Nesrin Seyhan	Gazi University Fac of Medicine, Biophysics Dept., Ankara	nesrin@med.gazi.edu.tr
	Ayse Canseven	Gazi University Fac of Medicine, Biophysics Dept., Ankara	
	Abdullah Rasit Gulhan	Telecommunication Top Council, Ankara	
	Consultants		
Italy	Paolo Vecchia	National Institute of Health	Viale Regina Elena, 299 00161 Rome, Italy vecchia@iss.infn.it
Czech Republic	Jan Musil	retired	musil@szu.cz

Report on Task 3. *Organization of two seminars for the WGs for standard harmonization in the field of RFR.*

We organized two partial international meetings as a part the International EMF Project, and one national colloquium. For the international meetings we used the seminars organized by WHO, and the respective national organizing committee.

The first one was at the time of the Eastern European Regional Meeting and Workshop *"Measurements and Criteria for Standard Harmonization in the Field of EMF Exposure",* and WHO EMF Standards Harmonization Meeting", held in Varna, Bulgaria, 28 April to 3 May 2001. There, on 30 April we organized a round table where we gathered scientists from Russia, Poland, Czech Republic, of course from Bulgaria. There we discussed the following topics:

- The start of the project;
- The aim of the standards harmonization;
- The misunderstanding – in languages, in protocols of the studies in the west and the east, and in criteria for developing standard limits;
- The ways for future collaboration;
- Non-thermal effects and long-term exposures.

The second meeting was at the time of the WHO Meeting on EMF Biological Effects and Standards Harmonization in Asia and Oceania, 22 – 24 October 2001 in Seoul, Republic of Korea. The participants of the partial meeting for the project were representatives from Russia, China and Bulgaria. There we discussed the following:

- SAR and "dose approach" – similarities and a possibility for their use in non-thermal or long-term studies;
- Standard limits and non-thermal effects;
- The level of the eastern and western science in the field of the electromagnetic biology;
- Future collaboration in the project.

The national seminar was organized in Bulgaria, "Gyoletchiza", mountain "Rila", as the 23rd traditional colloquium "Physics in Protection the Human Being and Environment". The special topic discussed at the meeting was "Ecology and Risk Communication". The main report as a part of this project was the following:

M. Israel, V. Zaryabova, P. Todorov – *Risk Perception, Risk Communication and Risk Management",*

Definitions of risk, exposure limits, criteria for developing standards, also the possibility to reach a dose/effect relationship in the field of standardization of ionizing and non-ionizing radiation were discussed.

Results/Deliverable No.4: It was reported at the meeting of the International Advisory Committee (IAC) of the WHO International EMF Project in Geneva, 2001, that the meeting in Varna achieved the required results. Some of the main results were the following:

- *First time speaking in a common language (East scientists and others)*
- *Understanding in:*
  - Criteria for evaluating standards (replication and peer review publications)
  - Models for developing standards (SAR and dose approach, induced currents)
- *General agreement for:*
  - ICNIRP guidelines as a basis for further discussion;
  - Terminology;
  - Standard protocols;
- *Consolidation of ideas;*
- *Uncertainty factors;*
- *Extrapolation from models, animals to human body.*

Report on Task 4. *Description of the method and way for setting standards in the past - in committees formed by some East European countries.*

The idea of this task 4 is to describe the method used in the East countries for developing standards in the past. Such detailed description would be a possibility for the west specialists and scientists to receive information how the discussions in the past led to a new standard in the East countries. That is important because this information would solve most of the problems of misunderstanding between the schools in standards' setting. It could help in an international way for developing common methods for creating standards for RFR worldwide.

Generally, the development of standards for human exposure to different physical factors have been worked out using the theory of energy interaction between the physical energy and the exposed object.

In the general case three major problems should be resolved at hygienic standardization of the external environment for humans:

- aim of standardization;
- physical standardization criterion, i.e. the normalized parameter (range and measurement units) and
- principle of identification of normalized quantities.

The restriction of the parameters of different factors of the external environment effecting humans in their work activities or everyday life could have different goals:

1. For the purposes of occupational and non-occupational safety, i.e. elimination of the possibility for hazardous and causing invalidity effects. Such norms (exposure limits) are usually determined on the basis of experiments on animals considering the cases encountered in the workplace and ambient environment.

2. For the purposes of occupational hygiene as a warning for occurrence of occupational diseases at a later stage as a result of the factor's effect. In these cases the basis of the standardization is formed by experiments on animals and the clinical indicators related to occurrence and particular signs of the disease.

3. For the purposes of ergonomics for realization of optimal conditions for maximal work capacity at minimal strain of the functional activity of the organism. These forms should be based on studies on the effect on changes in work capacity and production quality.

4. For the purposes of everyday life and residence (environmental) hygiene in relation to the conditions providing the best well being by subjective assessment of the quantities of the normalized parameter (statistical survey).

As the factors of the external environment usually act in parallel, the problem of selection of a physiological criterion for their standardization in the general case is brought to choice of a criterion for assessment of the adaptation limit, i.e. the limit of admissible degree of functional change that does not provoke future pathology at the

effect of dosed irritants. It is reasonable to conduct the search for such a criterion in studying the effect of irritants on the energy metabolism in the systems regulating the

vitality and work capacity of the organism as a whole and its realization through the complex methods of psychophysiology, physiology, biochemistry, histochemistry and morphology enabling the sufficiently full characterization of disturbances and recovery of the relevant systems.

The interaction of the human organism with the changing conditions of the external environment always cause change in its energy and material balance accompanied by transformation of the internal energy in the organism and change in the internal metabolic processes, forming as a response reaction of the entire organism to the external irritant. For physically impacting external factors the disturbance of the energy balance of the organism is primary and the disturbance of the material balance is a sequence.

When studying the impact of physical hazards on humans, such as noise, heat, light, and other factors the degree of physiological changes emerging in the organism is compared to their energy characteristics.

Here we shall discuss another physical hazard as an example for physical effect – vibrations. When conducting the occupational hygienic assessment of occupational vibrations affecting humans and at studying the receptor reactions of the vibration irritant, the researchers have characterized this process through shifting amplitude or through acceleration without providing neither technical nor physiological reasons for the choice of just those kinematical parameters as characteristic indicators.

This discrepancy in the assessment of identical factors has served as an onset for studies oriented to checking the energy effect of vibrations on human organism. In relation to the main task for scientific background of hygienic norms these studies aimed to determine mainly the relative indicators of the relationship between the impact direction (X, Y, Z), magnitude of response reactions of the sensor and some other systems of the organism. The qualitative-quantitative characteristic of the impacting resonance energy (vibration energy) was also basic, without though studying in depth the mechanisms of the variable and inter-related internal processes occurring in the organism as such studies, as a rule, are a subject of general and concrete physiology.

The method applying energy theory at developing exposure limits is widely popular and approved during the long practice of physiological-hygienic studies on the extent of unfavorable effect of the factors of the external environment on human organism.

In the general case, the hygienic norms (exposure limits) do not provide full warranty that the systematic and long-term effect of external environmental hazards on humans will not cause unfavorable sequences. This is explained not so much by the shortcomings of hygienic standardization developed for average conditions, but with the individual features of human organism, with the changing work and everyday life conditions and with other accompanying hazards.

In relation to technical progress, changing working conditions, changes in everyday life, the exposure limits should be considered temporary; they should be periodically reviewed for decreasing the exposure parameters with continuous transition to limits that are not evidenced to cause pathology, to ergonomic norms.

The criteria and philosophy for developing exposure limits in the East countries is described in details in my presentation at the meeting in Varna, Bulgaria, 2001, presented here in **Annex 1 (Task 4):**

> **M. Israel** - *Philosophy of Standards in Eastern Europe and Ideas for Standards Harmonization*, Proceedings, Eastern European Regional EMF Meeting and Workshop "Measurements and Criteria for Standard Harmonization in the Field of EMF Exposure" and WHO EMF Standards Harmonization Meeting, Varna, 28 April – 3 May 2001, Bulgaria, Editors: M. Israel, M. Repacholi, pp.67-74.

The scientific-technical co-operation within the East European Economical Union (COMECOM) proceeded in several directions. This co-operation was bilateral and multilateral. A "Standardization" direction was individually established.

Standards were developed and approved or equalized in the COMECOM member-countries in several ways:

1. Direct acceptance of the system of standards in a particular field of one country which has this system fully developed.

The other countries translated it in the national language and introduced minor changes. This is almost the same route that we follow now at implementing the EC (European Community) standards. That was the way to implement in our country and in some other ex-socialist countries the system of standards for technical safety (labour protection) of the USSR.

2. Development of standards on the basis of recommendations or ready ISO standards versions.

The draft of COMECOM standard was usually developed by a country which had a representative at the relevant ISO Technical Committee. This representative participated at all workshops as a member of his/her country delegation.

3. Development of COMECOM standards on the basis of enacted national standards.

The draft standard was developed by one of the countries that had already submitted an acting standard, on the basis of regulations of mandatory or recommending nature and/or results from own scientific works submitted by other countries.

4. Development of standards based on the final result of co-operative scientific research.

The themes for scientific research were identified as follows: each country submitted proposals for co-operative work on issues that it had already developed individually and had obtained certain results. These proposals were submitted to the other countries (respective representatives at COMECOM bodies) and each country addressed them to the relevant institutes, potential co-partners for discussion and application for joining the work. At the first joint meeting of the potential co-partners the particular topics were approved (with one task or with several sub-tasks) for joint co-operation, if more than two countries expressed interest in this work. If an issue was of interest for only for two countries, it was developed bilaterally.

At the first workshop (time and place set by the relevant representatives at COMECOM) the thematic plan was compiled, contractors were defined, the particular plan-programs were developed, the output was defined as well as the time and place for the next meeting (such meetings were held once a year). Between the meetings there was information exchange. The leading contractor was coordinator and responsible for the task execution. Such co-operations usually lasted 3 to 5 years.

Many themes (projects) resulted in a draft standard. The draft standards in the field of technical safety and occupational hygiene referred to: terminology, classification, safety requirements, requirements to measurements, maximal permissible values (concentrations) of particular environmental or workplace factors, etc. These draft standards then were submitted to the Standardization unit for inclusion in the program for development of the final regulation.

This program (plan) was compiled on the basis of COMECOM draft standards proposed for development by the above mentioned sources. The program was approved at a meeting of representatives of national standardization bodies. The responsible executives submitted the first drafts for coordination to the national standardization body of the co-partner country. These bodies submitted the drafts for statement to the relevant competent institutions. After compilation of the received remarks and statements the final statement was submitted to the leading contractor, who, based on the statements submitted by the co-partner countries elaborated a list of remarks. This list was discussed at a meeting with representatives of particular specialists in the relevant field from all co-partner countries. At this meeting a second draft standard was elaborated which the leading contractor edited, printed and submitted to the co-partners for statement. The procedure following was the same as that for the first draft. The final standard approval was made at a workshop of specialists from all partner countries. The final adoption of the standards was made at a meeting of representatives of national standardization bodies of the relevant countries.

The workshops with the specialists from all co-partner countries were organized once or twice a year depending on the particular standard.

Results/Deliverable No.7: We are preparing this part of the report for publication.

PHILOSOPHY OF STANDARDS IN EASTERN EUROPE AND IDEAS FOR STANDARDS HARMONIZATION

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I. INTRODUCTION

In this presentation I would like to compile the thoughts belonging to certain scientists and philosophers known all over the world related to hygienic standards through my views. As a beginning I would like to discuss the term "norm" (which is the basis for developing "exposure limits" and "standards") on the basis of ideas quoted by V.P.Petlenko, M.L.Reznik yet in 1977 in the Proceedings of the Institute of Occupational Hygiene, Moscow.[3]

The term "norm" is not new for medical philosophy. The health and disease issue, norm and pathology has been a focus for physicians from Hypocrite to nowadays. It is sufficient to quote more than 200 existing definitions of "norm" and "pathology". The WHO did set recently a unique definition for the term "health" – basis for definitions for "norm" and "pathology". A. Kettle introducing the term "average human" could be assumed as one of the founders of the new science on standards in the 19th century with the implementation of statistics. This "average human" should possess average physical, moral and intellectual characteristics and each deviation from them is considered an anomaly. This definition underlies the originating average statistical term "norm" and the related philosophical approach is a part of Kant's aesthetic theory. Of course, with the time the quantitative assessment methods undergo a sophisticated development – from the arithmetical average value to quite significant probability-statistical data.

At present the mathematical methods enable the determination with substantially good precision of different human parameters related to human health and activity. Nevertheless, even now, modern theoretical medicine assigns a critical evaluation to the average statistical understanding of "norm". Besides averaging physiological indicators, the average statistical assessment does not account for the novelty, which could prove to be a development tendency of the living system. Assessing the "normal" we do not assess "abnormality" from the viewpoint of progressive or regressive purposefulness.

The opposite approach based on individual physiological characteristics of the organism or their comparison with the so-called "prime" at the age of 20–25 is also under criticism.

The failures to define the term "norm" are determined mainly by the complexity of the interactions within the organism and with the environment.

The parallel usage of the terms "norm" and "standard" ("or limits") also provides problems at assessment of the interactions. The norm is objective, individual, dynamic, corresponding to optimal status of the organism. The term "standard" is associated with subjective contracting acts between specialists (conventions), it is related to elaboration of standards, models, patterns, and is conventional. Subjectivism results in approaches at setting norms (limits) – the differences in some hygienic standards reach tens and hundreds times.

At present in the "standard" the variety of the phenomena is deliberately brought to schemes allowing the stipulation of one or other interaction processes. The degree of closeness of the exposure limits (standards) to objective norms could be addressed depending on the set of phenomena covered or stipulated by the standards.

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The standard reflects the degree of knowledge on the subject and the norm – its real state. Consequently the task for development of scientifically based standards lies in maximal approximation to real norms.

In fact, there is no such science as "normology". Nevertheless it has its methodology – from the understanding of the term "norm" to proceed to development of a system of philosophical principles of the norms theory. The modern norm theory should compile data from physics and engineering, medico-biological, natural sciences, social sciences (the latter for juridical, ethical, esthetical norms).

It should not be forgotten that in the course of transformation of environment the adaptation-accommodation abilities of the organism could lay behind environmental changes.

II. PHILOSOPHY OF SOME EASTERN EUROPEAN STANDARDS

1. Terms and definitions

"Risk" is the term moving the research of developing exposure limits for different hazards, also concrete for electromagnetic fields (EMF). I am not going here to advance the theory of risk, and to discuss the ways and methods of risk assessment. I want to mention only, for instance, what is risk of exposure to ionizing radiation - a synonym of a probability of a harmful effect. There are opinions discussed in the Eastern European Countries (EEC) to use the same method to develop exposure limits for EMF exposure as that used for ionizing radiation. As a result, some precautionary approaches are used now in some countries similar to these suitable for ionizing radiation. Also, the fundamental dosimetric quantity in radiological protection is the absorbed dose. This is the energy absorbed per unit mass and its unit is the J/kg, similar to the unit "specific absorption" for non-ionizing EMF exposure.

The most important in the conception for developing standards not only in the EEC is the threshold conception, which is still in dispute for ionizing radiation. This means that in the Eastern European standards Threshold Limit Values (TLVs) and Maximal Permissible Levels (MPLs) are established.

TLV is ***the hazard's value which produces periodically or for the whole lifetime effect on humans without causing somatic or mental disorders (including latent or timely compensated conditions) or other alternations of health state out of the limits of adaptation reactions, which could be detected by the current methods at the moment or in a further period of life of the present or future generations***. Thus the compliance with TLV should preserve (avoid changes in) the average life expectancy, physical development indices, higher nervous activity state, work capacity, behavior, reproductive function, capacity for adequate adaptation to the environment, biochemical and functional human constants.

2. Types of standards

An additional question is one or two tier standards. The conception in EEC for developing standards is to use two types of exposure: occupational and environmental (for the general population). There is, also, discussion about the possibility to separate an additional exposed group – non-occupational exposure using different safety factor settled between those for the occupational and for the environmental exposure. The exposure of the general population also is divided into exposure at home (in dwellings), outside the buildings (living area), and at places where temporary exposure may occur (agricultural lands, parks and gardens, places for recreation, etc.).

One different example is the approach used in the Polish standards. Three zones have been introduced to evaluate exposure of different people: dangerous, intermediate, and safety zones. The maximal admissible levels of exposure (similar to the TLVs) are applied for the dangerous and intermediate zones, the first one for short time exposure, the second - for longer time (more than 2 hours). The Czech standard also is dealing with different duration of exposure – short time, middle time intervals, and long-term, also applicable for different part of the population. The Russian,

Bulgarian standards for occupational exposure, are developed for limits used for every exposure duration. In the latter, time (and the energy) can be calculated using equations discussed below.

One approach is common for most standards – TLVs exist for every type of exposure, MPEs should be calculated depending on duration of the exposure.

3. Methods for developing standards.

I think, this will be strange for more of you but that is the philosophy of thinking of more of the Eastern European scientists working in the field of developing exposure limits. Here, I would like to present you now the publication of Prof. Savin from the Institute of Occupational Health in Moscow, used as a philosophy in most Eastern European countries for hygienic standardization [5]. Following this paper, the following changes have to be taken into account when assessing the exposure:

1. Qualitative changes in the course of biological processes.
2. Quantitative changes in the state of biological processes out of the physiological standard levels and resulting in the decrease of human compensation capacity to respond to environmental hazards or to overcome unusual psycho-physiological conditions.
3. Occurrence of additive effects of exposure with cumulative characteristics, leading at long term exposure to changes in the biological processes exceeding the permissible quantitative indices.

The following classification of the thresholds of electromagnetic radiation exposure by biological indicators is given in the same publication:

5	Zone of harmful exposure
4	Zone of extreme effects
	Adverse effect threshold
3	Zone of adaptive response
2	Indifferent zone
	Threshold of radio wave sensibility (biological effect)
1	Below threshold-level

According to the publication of Prof. A.G.Subbota [7], which is also widely used for the hygienic standardization in Eastern Europe, the most informative indices for radio frequency injury are:

a. disorders of the CNS;

b. suppressed interchange of gases;

c. functional disorders of gastric secretion (signs of gastritis);

d. marked functional disorders of cardiovascular system (dyastonia, ECG changes);

e. long term functional changes and changes in the blood element composition;

f. marked decrease of human resistance to infections and other environmental factors (heat, cold and others);

g. constant metabolic disorders;

h. continuous hormonal functional disorders (menstrual disorders, changes in the fertility and offspring indices).

Structural changes in human system, such as cataract, epithelial degeneration of testicles, ulcer etc. should be considered as obvious indices.

Similar philosophy was used in standardization from Prof. Shandala (Kiev), Prof. Paltzev (Moscow), and from some East European researchers. Only the definitions of the adverse effect (the MPE level) are on different level on the scale presented above. [2]

The TLVs and the MPE levels for electromagnetic (EM) exposure in most of the EEC standards have been developed on the basis of a complex of methods: hygienic, clinical-physiological, epidemiological and experimental methods.

A short description and cause of using these methods are:

- hygienic methods: to evaluate the parameters of the exposure, including the duration of the exposure;
- clinical-physiological methods: to evaluate clear manifested harmful effects and changes in the physiological functions;
- epidemiological methods: to establish the future (secondary) effects;
- experimental methods: to study the biological effects of the EM radiation.

Different experimental methods are the main ones for developing limits because of the non-specific functional and pathological changes in the organism.

Hygienic methods include two groups of methods for exposure assessment – exposure measurements and dosimetry. The exposure assessment can be made using the following:

spot methods - based on single measurements of the incident EMF parameters at the assessed work place or at men's residences;

dosimetric methods - they comprise personal dosimetry during the work shift, evaluation of the time duration for an individual or for a group with homogeneous exposure, direct dose measurements, etc. Direct dosimetry includes methods for assessment of the energetic loading of the organism, induced currents, whole-body or localized SAR, etc.

Prof. Paltsev in [2] speaks, also, about three different zones of biological reactions of the organism:

- biological effects;
- a progress of adaptive and cumulative processes as a manifestation of adverse effects on the systems;
- pathology.

The exposure limit for adverse effect should be the border dividing the zones of active adaptation and pathology.

When the absorbed energy is considered, different methodology for studying the exposure limits of EMF exposure is used in dependence on the wavelength:

- with a wavelength essentially exceeding the size of the biological object – frequency up to 30 MHz;
- with a wavelength much less than the size of the body;
- with a wavelength commensurable with the size of the body or with the sizes of different parts or organs – frequency between 30 MHz up to 10 GHz and above.

The exposure limits for adverse effect evaluated on the basis of extrapolation and by numerical methods of calculating the induction currents/absorbed energy in phantoms are a better approximation than the direct transfer of data from animals to human body. The uncertainty of such extrapolations could reach to 50-100%, while for animal extrapolation it reaches 1-2 orders. [3]

What does non-thermal effect mean? It exists when whole body temperature rise is not observed. The heat distribution could be non-uniform, and "hot spots" could be available in field strengths below those causing thermal effect.

The interaction mechanisms of the EMF exposure of biological tissues have essential meaning for evaluation of exposure limits. Fundamental manifestation of such interaction is the heating of the tissue.

4. Safety factors

Now, short debate regarding safety factors (coefficients of hygienic reserve, as the term is in the EEC). Historically, and as the most used value of the safety factor, is 1:10. In the EEC there were ideas for the low frequency ranges where the electric and the magnetic field strengths have to be evaluated separately, a factor of $\sqrt{10} \approx 3$ was proposed for exposure limit to every field. When simultaneous exposure of the two field components E and H is available, an additional coefficient of $\sqrt{2}$ had to be multiplied with the first one. The final safety factor for exposure limits for frequency up to 300 MHz becomes about 5.

In most of the Eastern European standards, the safety factors are 1:10 for occupational exposure, and 1:50 for the general population. For non-occupational exposure (occupational exposure in working area, but for people not engaged with EMF sources), the discussion is whether a safety factor of 1:20 to 1:50 to be applied.

Little is being done on combined effects of EMF and various other physical, chemical and other hazards of the environment. There are few standards (Russia, Bulgaria) where attention on combined effects of EMF and ionizing radiation or hyperthermal conditions has been taken into account using an additional safety factor of 1:10.

5. The "dose approach" in standardization

The "dose approach" – "the energetic loading of exposure" is the most often used term in the EEC standards. Historically, it was accepted in the late 60-s and the early 70-s in some EEC – Poland, Czechoslovakia, the Soviet Union. This approach comprises to evaluate together the measured values of EMF – field strengths (electric E, and magnetic H), power density S, with the duration of exposure T in hours or in minutes. The energetic loading values are defined as $E^2.T$, $H^2.T$ or $S.T$, and they are in direct proportion to the incidental electromagnetic energy. If the angle of the incidental energy to the long axis of the human body, and its section area would be taken into account, it is possible to connect these values with the whole body or local SARs.

Prof. Savin in 1979 [6] discusses the basis of the dose approach: the MPE has similar to hyperbolic dependence to the duration of the exposure. In the same guide Subbota and Tchuchlovin [8] give a simple equation for dose evaluation:

$T = \dfrac{W}{kP}$, where T is the duration, in min; P is the power density measured; k is a coefficient related to other exposure characteristics (efficiency); W is the incidental energy density.

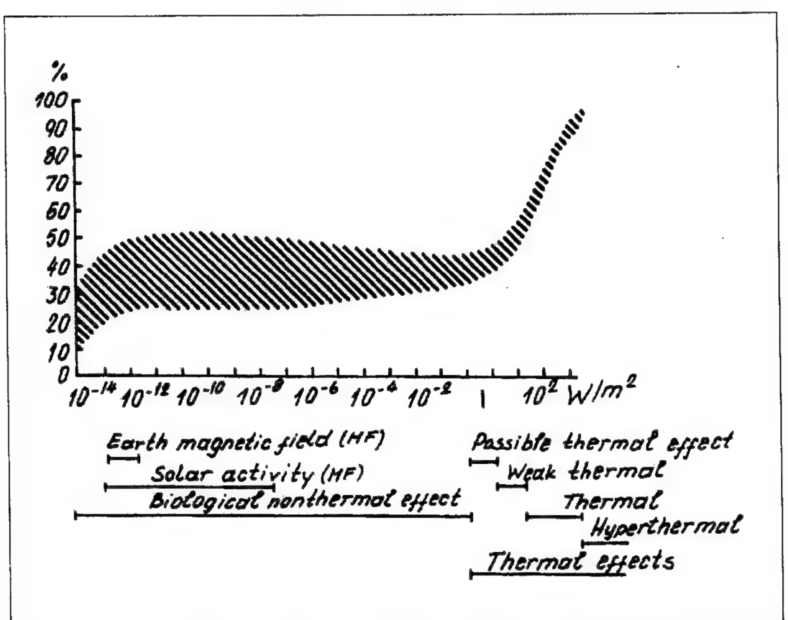

Fig. 1. Dose-effect relationship.

The dose approach gives the possible exposures to different sources of radiation to be added for persons working in several workplaces, for persons exposed to different frequencies and field strengths, or for different exposure duration (for instance - 24 hours). Most of the Eastern European standards describe methods for summing the exposures.

Here, it is presented a figure from Kudrashov et al. [1] shown a type of dose-effect relationship dividing the thermal from non-thermal effects (Fig. 1).

Many countries have their own standards (or parts of standards) dealing with intermittent or pulse electromagnetic radiation. The rationales of most of them are the data of studies having shown higher biological activity to exposure to pulse radiation than to continuous waves. Some of the standards introduce special types of radiation depending on the sources: rotating, scanning antennae. Most of the evaluations are made on the basis of the existing sources of radiation, not only on biological evidence.

III. CONSIDERATIONS FOR STANDARDS HARMONIZATION

Now, let go to standard harmonization.

I will not discuss now the way for such a process. We will do this on many meetings and joint projects between specialists from different countries and schools. Now we are going step by step to this framework that WHO Project gives us the possibility to develop.

The first step to harmonization is to change the approaches for developing exposure limits. Because of political reasons insufficient emphasis is placed yet on the requirement that the exposure limits should not be an obstacle to scientific-technical development and implementation of new technologies. The hygienic science is regarded as a social science and although there is no centralized financing of medicine any more, the political and historical heritage does not permit the thinking to turn to new approaches to norms.

Yet globally the environmental exposure is distinguished from occupational exposure. It is time to consider the approach for assessment the physical factors for 24-hour exposure, to proposed by the European Union Directive for Physical Agents, in 1992 [4] There, the overall strategy is founded on the obligation to reduce the hazards to the lowest attainable level. This strategy defines three hazard zones:

1. Black zone (banned) – for EMF it must be the forbidden zone where whole body SAR is above 0,4 W/kg;
2. Grey zone – where EMF have to be monitored or where precautionary approach have to be applied;
3. The White zone – safe zone where general population can be exposed to EMF up to 0,08 W/kg.

The top border of the white zone is the threshold level where exists a probability for adverse effect if human body staying without any protection or for a long time. Below it people can live safely without any harmful effects. The upper boundary of the gray zone where is the beginning of the black one, is the threshold limit value for occupational exposure.

This will lead to a more precise assessment of biological effects as, particularly for EMF often the outdoor and home radiation values are higher (or the duration is longer) than occupational values.

Standard harmonization is possible if we settle the differences in:

a) Terminology;
b) Measurement and exposure assessment;
c) Dosimetry;
d) Standard protocols for hygienic and biological investigations;
e) Criteria for developing exposure limits;
f) Methods (as a complex) for different type of biological research;
g) Philosophy of limits, etc.

To get this aim (standard harmonization) we propose the following activities:

- to organize a working groups for discussing terminology, different criteria of standards; criteria for evaluating established health effects, uncertainty factors, etc.;
- find a common viewpoints and tangents between different criteria of standards and to use it for an international proposal in future. That is the reason to discuss the problems of measuring, exposure assessment and dosimetry as parts of setting terminology, methodology and criteria;
- to create expert groups in different topics of standardization which can work in workshops, meetings, by Internet also;
- to organize meetings for discussing the socially-responsible standards and approaches, industrial concerns, scientific evidence, safety factors, non-thermal and long term effects; political pressure; demagogic principles, economical situation and standard development process;
- to support new research studies which can find some decisions connected with criteria for standardization and for exposure limits;
- to review a part of the Russian and other literature in Slavonic languages connected especially with philosophy, rationale and criteria for creating RF standards; some significant studies to be replicated in other countries;
- find more specialists from the East to be involved in the process of an international harmonization of standards.

Most of these issues we are going to discuss here, at the meeting in Bulgaria.. We hope this process can be shortened if we all have agreement with such activities, also between different scientists in the world.

Here, we want to present an example (in Appendix 1) showing how to reach the space (orthogonal, 3-dimentional) where the same or similar approaches are used from the two discussed school of standardization.

IV. CONCLUSION

In conclusion I would like to mention that the Eastern European countries have introduced EMF norms in the early 60s. The results of the studies have been discussed annually at workshops and meetings of specialists from the different countries. Often norms have been elaborated through joint projects involving two and more countries.

The applied methodology in eastern countries has its shortcomings. First of all, ranging medical indicators and those of changes in organs and systems of the organism first hides the comprehensive mechanisms of EMF interaction with tissues and cells, although the knowledge of interaction mechanisms cannot always lead to correct development of regulations. Nevertheless, essentially most regulations in these countries are based not only on short-term and thermal effects, but also on long-term and non thermal effects, which should be the basis for setting norms globally as well. This is the only way to help persons with the so-called "hypersensitivity" which phenomenon could prove to be very serious for future generations. In fact there is a tendency for consideration of long-term effects in the West standards (example IEEE/ANSI).

Finally, we are scientists and expressions like "there is no animal of the kind" are not serious. That is why we should not accept categorically the statements of some scientists:

- we do not believe in long-term effects;

- SAR is the only a quantity which enables us to determine the effects of exposure to RF/MW radiation;

- only the thermal effects are reliable at electromagnetic impact;

- we don't believe in relationship between EMF and cancer;

- epidemiological studies nowadays are not serious, etc.

Instead of using categorical expressions for negation or confirmation of our theses, we would better seek a way to understanding between different standardization schools. We have now the possibility to do this because of the new global political situation, and the EMF Project is the opportunity to think positive on this process.

ACKNOWLEDGEMENTS

The author thanks to Prof. Zdravko Paskalev (*National Center of Radiobiology and Radiation Protection, Sofia, Bulgaria),* for his ideas in the standardization of ionizing radiation.

Appendix 1

Example

Israel M. [1]**, P. Tchobanov**[2]**,**
[1]***National Center of Hygiene, Medical Ecology and Nutrition, Sofia, Bulgaria***
[2]***Military Hygienic Inspection, Military Medical Academy, Sofia, Bulgaria,***

Let us illustrate a harmonization of biological criteria with an example related to marked thermal effects, visible on Fig. 1 [1].

Let us consider a case of EMF effect when thermal release exceeds the organism abilities to provide thermal comfort (area of S-like increase of the effect in the "dose-effect" curve).

In this case it is possible to show that the development of thermal effects towards growing intensities of EMF (S.t $\geq$10 mW.h/cm^2) is with substantial dispersion about and below the limit 100% (MPE), and has several alternatives for recognizing the next state of the organism: most often an indefiniteness is reached, which can be revealed only through selected additional experiments. Further, in semi-quantitative evaluations and in "dose-effect" terms the difference between standardizing is up to 10 W/m^2 (1 mW/cm^2) and the reaction at higher values can be expressed as protective, described through parameters or in destructive changes. If it is described analytically, the expression will be similar to that for a sea wave breaking against a low beach (Fig. 2).

What should the adopted philosophy be, so that it would be suitable for further global harmonization?

Standardization philosophy leads to the necessity of unity in the diversity and to equity in the variety. Such convergence type provides to the globalized community united civilization and technologies. Unfortunately we are not yet ready for hygienic standardization conforming to national and regional, race-specific biological features. As already mentioned, the initial difference of 1000 times by maximal admissible level between Eastern and Western standards decreases but at present this is not an intentionally controlled process. The East proceeds from very weak exposures with slow effect accumulation towards intensified exposures with increasing effects still staying within the frames of the concept for specific non-thermal EMF effect. Western hygienic standards lately evolve following the opposite direction.

On the other hand more and more teams developing standards "move" from short-term to long-term exposures and the discussed East European standards comprise also short-term evaluations at least as a design.

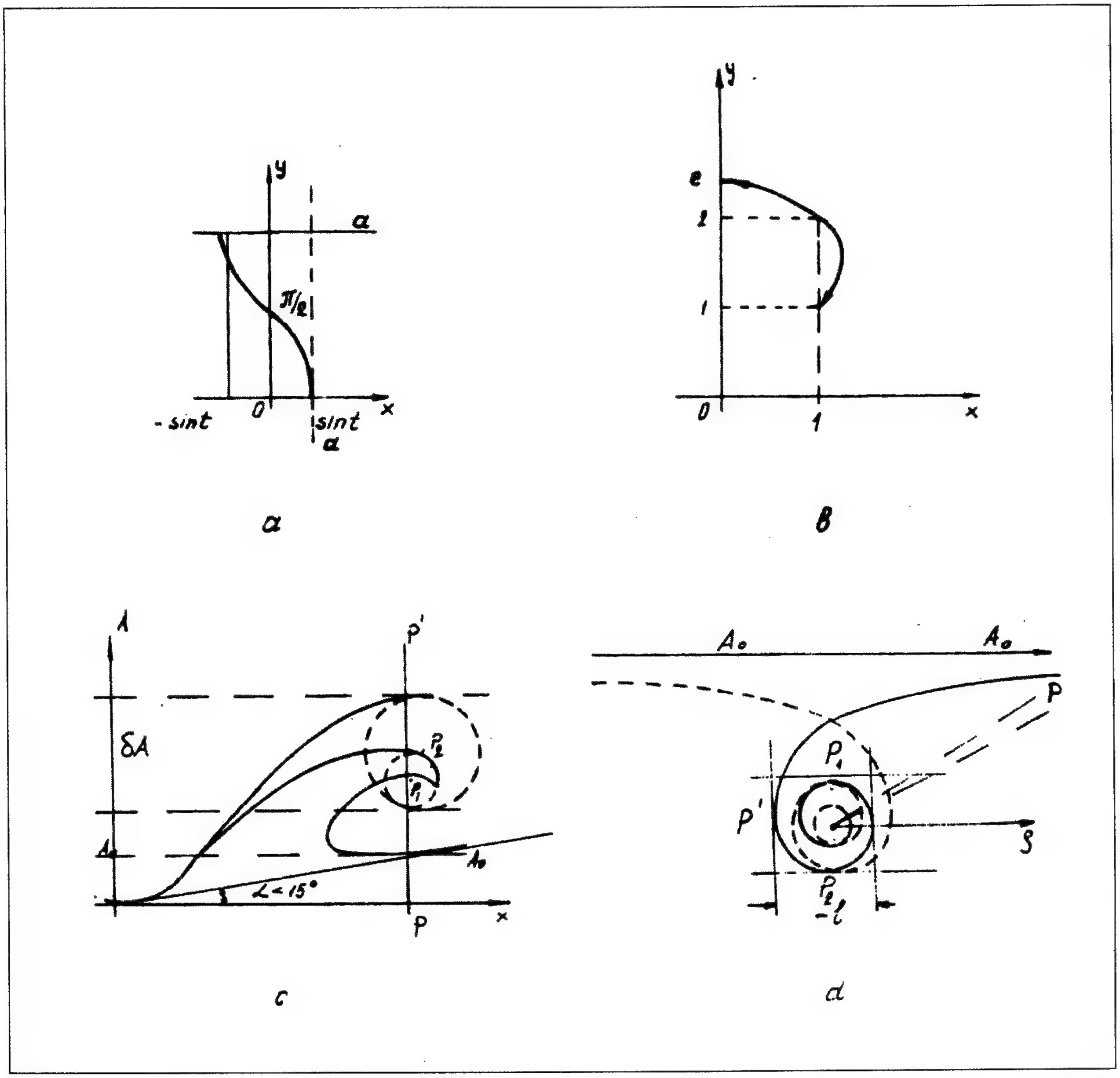

Fig. 2. Sea waves breaking.

It seems that there is a possibility to cover the hygienic measurement data with two phase spaces, where the hygienic evaluations would be quantitatively comparable. Those two coordinate systems could have a common origin as the bases used by both East and West for biological background of the indicators which turn into "health zone" parameters, described by the hygienic standard are practically the same. In the field of dose assessments this is a scale issue: dose values are graded into intervals by intensity and exposure duration. For example, depending on the interval dimension, it contains distinguished or united elements. For harmonization purposes we can replace the uniting of elements from such a set with summing by "general quality" index – exposure degree or intensity. The latter is a sum by qualitative or quantitative characteristics. Let us assume the "quality intensity" ("effect depth") to lie within the whole interval of variables (e.g. energy index of exposure). Let us as well limit the set "dose-effect" only to a signal from falling EMF irradiating the measuring device at a distance of "R" (where the exposed individual works or resides) and the re-irradiated EMF from the area borders through which the power density is determined by effective values. Let the argument be the signal amplitude – effective intensity of total radiation – a function of the "reverse distance", $1/\sqrt{(\lambda R)}$, where λ is the wavelength. Our previous studies [a poster in San Antonio, Dec.2000] show that this amplitude has a resolution in (conditional) real and imaginary components; for 80% of the possible amplitudes in the interval λ from 0.0073 to 1500 m [9], the

components are positive, i.e. their imaging points in the "dose-effect" space fall in one octant. These points gather on their three coordinates in subclusters with different magnitude and density, clouds of hierarchical order with negative index (Fig. 3).

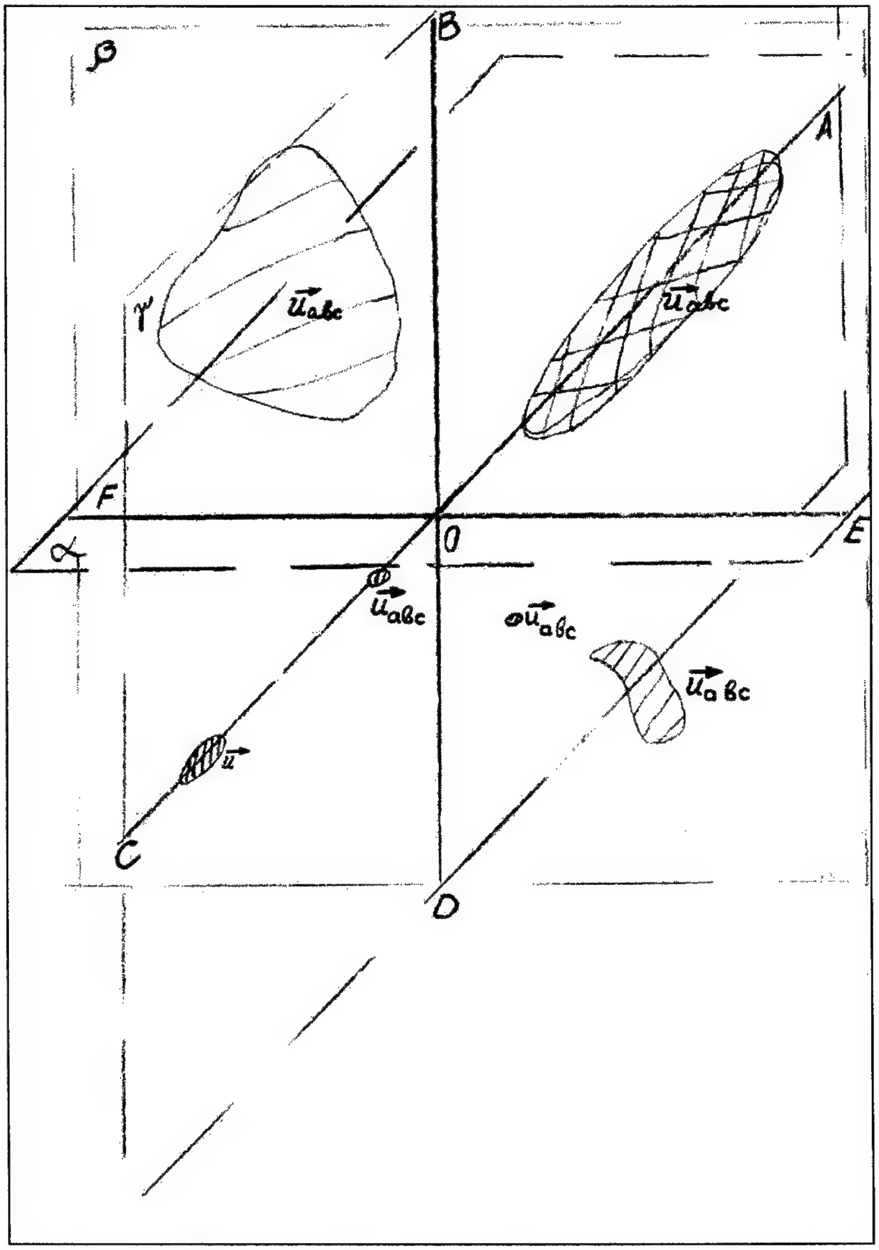

Fig. 3. The "dose-effect" space.

Let us select a projection in Hilbert or at least Hausdorf space, in which the generalized indefiniteness principle in a subspace or evolute of the basic (vector, interval) space is valid. Depending on the differentiation of the initial points in the projected group as a function of the exposure intensity m, the selected summing by unlimited number of elements (eventually of all recognized points) provides an infinite row, which sum can be presented by Bessel functions of I type and "m" order [10, 11]. We receive a function of differentiation of magnitudes of electromagnetic impacts with close values of $S[\mu W/cm^2]$. Because of the difference in the argument magnitude, which is the hygienic limit itself for two types of standards based on thermal effect and another type respectively on specific, these Bessel functions have resolutions by differently presented arguments. The latter means that the threshold doses (those that should be adopted as hygienic norms) fall into different intervals of measured power density (S). In these intervals the exposure intensity as a quantity is a solution of different differential equations. For them it is characteristic that the integration is not random but on precisely defined borders – the intensities

could not be randomly selected. If we use the energetic doses for comparison, each pair of biological indicators, for which we would pursue approximation and harmonization of the two groups of hygienic standards of the East and the West, the difference between them would represent the length of a segment, for which it is the easiest to use quadratic form of impact intensity.

The selected example illustrates the following internal requirement of the standard harmonization procedure:

a) specialized studies selection, which should not be trivial or random but with strictly harmonizable characteristics – standard measurement, dosimetry and study protocols; pre-set group of biological indicators;

b) all standards should involve a parameter of the type energetic parameter of electric or magnetic field or of the energetic loading of the organism, i.e. quantity of absorbed energy per kg or g tissue live weight;

c) approach (philosophy)

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Main Results and Deliverables. Discussion

1. A database of RFR standards from:

Bulgaria – available standards and regulations
China – papers describing in details the RFR standards
Czech Republic – original standard, and a paper for the former one
Hungary – a paper describing standards and regulations in details
Poland – original standards
Russia – most of the standards and regulations original, others presented in papers
Yugoslavia – a paper describing the standard in details.

Also from several other (not East European) countries and international (national) organizations:

ACGIH – TLVs original
C.95.... – all of them as drafts
ICNIRP – original guidelines
IEEE – all drafts
Italy – a paper with details
Japan – original standard
The Netherlands - original
NRPB - original
Republic of Korea – description in details
Turkey – detailed description in the questionnaire's answers,
and many others.

Here we would not include copies of the standards. Most of them are available in our laboratory, and they are being prepared for including in the home page of the Bulgarian National Program Committee at the WHO International EMF Project.

2. Criteria and rationale used in the standards of the East European countries.

Description of the criteria for developing most of the standards in East Europe are available in the same paper cited in **Task 4**:

M. Israel - *Philosophy of Standards in Eastern Europe and Ideas for Standards Harmonization*, Proceedings, Eastern European Regional EMF Meeting and Workshop "Measurements and Criteria for Standard Harmonization in the Field of EMF Exposure" and WHO EMF Standards Harmonization Meeting, Varna, 28 April – 3 May 2001, Bulgaria, Editors: M. Israel, M. Repacholi, pp.67-74.

Regardless the unified method for developing standards in the East countries, there are many differences between the standards and regulations going from country to country. The concrete criteria described by famous specialists from different countries are

enclosed in **Annex 1 (Main results)**. The information is collected by the answers to our questionnaire, also from their presentations at different meetings.

3. Possibilities for agreement between different schools for developing standards. Viewpoints and tangents between them. Problems in the field of the standard harmonization in the world. Criticism to the ICNIRP Guidelines.

These questions are very important for developing international criteria for RFR standards. Here, in **Annex 2 (Main Results)** we present the answers to questions No. 8, 9, 10, 11 and 15 from specialists – participants in the project from different countries:

8. How do you adopt the criteria of the Western standards? What is your opinion about such criteria? Do you intend to accept their criteria in your standards?

9. What are your ideas for future development of standards:

- ***in your country;***
- ***in the East European criteria;***
- ***worldwide?***

10. Where do you see possibilities for agreement between different schools for developing standards? Please, show close viewpoints and tangents between different schools (East and West).

11. What kind of problems do you observe in the field of the standard harmonization in the world?

15. What is your criticism to the ICNIRP Guidelines?

Most of the opinions are the following:

There are **opinions pros and cons harmonization** of RFR standards. Some arguments that don't support worldwide harmonization i.e. not changing the current limits (practically keeping low level) are as follows (G. Thuroczy):

- New result of EMF research are coming
- New theories of EMF interaction are coming
- The current strict limits meet better the ambient EMF exposure levels in the environment accessible to public
- More close to the precautionary principle or approach
- Good message for the population
- Looking at the process in some Western countries
- Other social (political) impacts

Some arguments and aspects in the procedure of standard harmonization between Eastern countries and the other world are those supporting the change of the current limits (practically moving towards ICNIRP Guidelines):

- Not confirmed results at low level EMF exposure
- New information are coming from recent results of national and international projects (WHO EMF Project, etc.)
- Supporting the joining procedure to the EU
- Influences by the industry and multinational companies for the standard harmonisation
- Looking other countries and ICNIRP/EU guidelines
- Others.

The way for reaching such agreement for moving together to harmonized framework for RFR standard includes many steps. One of them is the persuasion that such change is necessary and possible. The agreement between different schools could be in supplementing the East and West viewpoints, but both should be supported by valid experimental data.

"Perhaps the goal, which should be achieved before the unified standards can be reached in the whole word, is to convince all states that they should abandon a national "pride" of its own results and take the opportunity to use results summarized in a common "pool" of scientific knowledge and evaluated for a possible health hazard by an acknowledged international organization." (L. Pekarek)

That is the first step. Following the logic we should change our own thinking, also those of the opponents.

In order to achieve the consent between different schools it is necessary to come to an agreement about the methodological approaches for developing standards. For this it is expedient to organize a working group of specialists from different countries and to commission them with the development of an agreed methodical document. For harmonizing the standards it will be useful to prepare an agreed adjusted International document entitled "Methodical recommendations for carrying out the studies directed to hygienic standardization of electromagnetic radiation". In order to elaborate this document it is expedient to create a working group consisting of scientists who have the experience of studies in the field of developing the national and international EMF standards. (V. Nikitina)

Next step has to be to harmonize the terms, exposure values and definitions in the standards. Terms and definitions that have to be discussed are described in the next point 4. of the report **"Main Results".**

Some additional important terms are: maximum permissible levels, permissible levels, controlled levels, exposure limits. Such terms as dangerous influence, harmful influence, threshold of harmful influence, threshold of harmless influence, threshold value must be unified.

Especially about the possibility to use different dose parameters (SAR vs. "energetic loading of the organism) there is a solution described in details in:

Israel M.- *Standards and Regulations for EMF Exposure in Bulgaria*, Eastern European Regional Meeting and Workshop "Measurements and Criteria for Standard Harmonization in the Field of EMF Exposure", and WHO EMF Standards Harmonization Meeting", held in Varna, Bulgaria, 28 April to 3 May 2001, Proceedings, Editors: M. Israel, M. Repacholi, Sofia, Foundation "Faraday", 2002, pp. 99-104.

Israel M., P. Tchobanov, P. Tomov - *Exposure Assessment of Electromagnetic Radiation in the Near and the Far Field Zones. Restrictions in the Dose Evaluation*, Eastern European Regional Meeting and Workshop "Measurements and Criteria for Standard Harmonization in the Field of EMF Exposure", and WHO EMF Standards Harmonization Meeting", held in Varna, Bulgaria, 28 April to 3 May 2001, Proceedings, Editors: M. Israel, M. Repacholi, Sofia, Foundation "Faraday", 2002, pp. 155-162.

Israel, M., P. Tchobanov *One Possibility to Settle the Differences between the "Dose Approach" and SAR Values* – Proceedings of the WHO Meeting on EMF Biological Effects and Standards Harmonization in Asia and Oceania, 22 – 24 October 2001 in Seoul, Republic of Korea, p. 120.

Original papers are available in **Annex 3 (Main Results).**

There is a variety of data that shows adverse effects on physiological and psychological parameters of the human being at levels that could be considered as "nonthermal". That is the reason that most of the scientists from the East would speak about harmonization only after agreement for including the following:

- long term effects to be considered in the exposure limits;
- results of chronic experiments;
- studying the influence of RFR on the most sensitive organs and systems of the organism;
- data of studying the remote consequences of the exposure;
- data from epidemiological studies.

Next problem is whether the temperature rise of 1°C is "normal" for the human being or should not be used lower limit for "thermal effect". Especially the specialists from Turkey are speaking for thinking about new lower limits for thermal effect.

Additional question is whether the thermal effect should be expressed only by the temperature rise. It is most important to take into account the organs and systems in the organism connected with the thermoregulation. The mechanism of thermoregulation in human body is triggered before (earlier) than the temperature rise, and could be detected physiologically (of course, out of the physiological norms).

Some specialists ask what the standard would be, based on only other dose parameters (not SAR), and how to reach an agreement if dynamical observations and cumulative effects are ignored.

RFR standards harmonization worldwide could be solved only after achievement of consent on the following positions:

- Definitions of the uniform/non-uniform approaches to the exposure assessment of EMF;
- Terminology consensus;
- Definitions of the exposure dose and possibilities for numerical conversion between different dose parameters;
- Evaluation of significance of the results of experimental studies;
  - Determination of priority of the EMF biological effects mechanisms;
  - Evaluation of significance of the results of epidemiological studies;
  - Determination of the significance of the results of human health state evaluation
  - Determination of principles of hygienic standardization of combined EMF exposure of different frequency ranges
  - And many others.(N. Rubtsova)

As a conclusion, it is impossible to reach an agreement without taking into account long term effects, the non-thermal effects, chronic (long time in epidemiological means) effects, also changes in the cardiovascular, autonomic nervous system, immune, sexual systems, also delayed consequences.

4. "Windows" and "resonance" effects in the criteria for exposure limits. "Special" terminology as "long-term" and "short-term" effects, "thermal" and "non-thermal" effects, "informational" effects, "adverse" effects. Physiological and psychological changes in standard limits.

Here, we are trying to explain the lower limits in most of the East European standards, and to define terms that are very disputable. An additional question is if headache, cardiovascular changes, effects on EEG, blood pressure, heart rate, sleep disorders, mental problems, changes in the autonomic nervous system could be factors to define "adverse effect" and to use them as criteria for standard development.

Using the answers of the questions No. 12, 13 and 14 from our questionnaire, received from China, Hungary, Poland, Russia and Turkey, the general opinion to all terms and questions is the following:

Long term effects of EMF are harmful and humans should be protected.
One definition for "long term" effect is: such effects which are registered in remote terms after stopping the influence of EMR. First of all, these are mutagenic, atherogenic, gerontological and oncological effects, disorders in the state of the posterity.

Short-term effects are such effects which are registered during or immediately after the influence of the factor.

Thermal effect is the raise of temperature in the human body as the result of the interference of the EMF and the body fluids, like in the microwave ovens, but the effect is much weaker. Today a thermal effect is understood as raising the temperature of the body. In my opinion (V. Nikitina), it would he more correct to take into account reactions of the whole thermoregulation system.

Non-thermal effects could be headache, cardiovascular changes, blood pressure, heart rate, sleep disorders, mental problems, changes in the autonomic nervous system, etc. Non-thermal effects are all effects not accompanied by raising the temperature of the body.

Informational effects are such effects that are registered at the low levels of the EMR factor and connected with the synchronizing influence of the electromagnetic radiation.

Adverse effects are such effects arising of which can lead to disorders in the health status.

In general, all these effects should be taken into account in developing standards. Some of the members of the WG think that also "windows", "resonance", "informational" effects should be taken into account.

Most of the participants believe that subjective disorders (headache, sleep disorders, worsening the memory etc., typical for RFR exposures, disorders in the central nervous, endocrine and cardiovascular systems, disorders of the reproductive function and the immunity are to be taken into account when developing the standards and testing their effectiveness.

Single participants think that headache, sleep disorders, mental problems, slight cardiovascular, EEG, blood pressure, heart rate changes can not be factors to define the adverse effects separately. But the proof, statistically significant changes which are overstepping the bounds of fluctuations of physiological norm, objectively registered

parameters of a state of cardiovascular and nervous systems in a combination to significant changes of a state of blood system, immune system, the biochemical parameters, the expressed morphological changes in main systems of an organism, and also influence on sexual function and posterity should form the basis for an establishment of a threshold of adverse effect.

Functional abnormalities of internal systems, including symptoms of dysregulation of autonomic nervous system control, are not a disease, but worse health status and should be avoided. Therefore, if the causal relation of such symptoms in EMF exposure could be documented (which is the case in certain groups of workers) and the thresholds of exposure levels could be identified, such symptoms should be used for development of standards for long-term exposures.

Many of these "disturbances" are biphasic (i.e. in the immune system), and this could be confounding in the process of developing exposure limits. The mechanism could be understood after studies with advanced molecular biological techniques, e.g. changes in 5-HT receptor and MF exposure symptoms published in BRAIN RESEACH Vol. 858 (1) pp.143-150

The Turkish participants think that the effects on children should be considered as high priority effects.

5. Precautionary approach in the standards.

Half of the researchers support that precautionary approach should be definitely included into the standards. The important viewpoints are connected with the following explanations:

People should be able to read at the same place what the risk is and how to protect themselves. This will increase public confidence.

The rest part supports that this principle could be useful, but it has no place in standards. As its application it could result in absurdity and full exception of an opportunity of use of technical achievements. Maybe it is unique acceptable (and that not always necessary) only for a construction of new EMF sources.

Probably, the precautionary principle is applicable for the majority of the western EMF standards constructed on the basis of SAR concept. For the hygienic norms based on an experimental establishment of a threshold of harmful action, using results of experiment from animals extrapolated to persons and using convenient safety factors, it would not be seen the basis for application of this principle.

6. Additionally, we could summarize the opinion of the East specialists concerning the questionnaire proposed by WHO in the Progress Report 1998/1999 of the International EMF Project for developing a framework for an international standard.

The No.17 in our questionnaire includes all the questions concerning this framework.

The viewpoints on this questionnaire could be a basis for finding a common language for developing an international framework for standard harmonization worldwide.

Here, we have summarized the opinions of the specialists, members of the international WG, created for this project.

Question a) Criteria to be used to evaluate research results

In general, no opinion on this question. Only in **Task 1** we (Bulgaria) propose such methods in details.

One short description proposed by the Bulgarian group is as follows:

- Scope of the studies referring to:
  - frequency range;
  - exposed group/staff/contingent;
  - study exposure area – near or far field;
  - number of studied objects aiming better confidence of the results;
- Proven confidence of the results:
  - study methods;
  - equipment;
  - studies conducted by – institute, laboratory (recognition or proven capacities);
  - qualification of the staff responsible for the studies;
- Proven reproducibility of the results
  - statistical deviation
- Searching for comparability of the published results obtained in equal conditions, equipment and staff qualification.

Question b) Detailed requirements for scientific rationale to support limits

Yugoslavia: Detailed research on the population exposed to EMF for the long period in the conditions that are now in the environment present worldwide, should be performed. Lab work is efficient, but long-term effects cannot be seen there. We are all nowadays exposed and the noticeable changes should be recorded, especially at the locations where the exposure is high. Good organization in gathering the data for the analyzed and the control group, and data organizing and analyzing are the only needs and so the advantage for it.

Russia: Described above in Annex 1 (Main Results)

China: (1) Assessment of health hazard for setting standards should rely mainly on the health status of personnel exposed to RF EMFs. The results of experimental animals and theoretical calculation should be supplemented to the human exposure data. In these cases, we may evaluate whether the really exposure levels are safe.

(2) Some investigations on the health effects of occupational and environmental exposure to different frequency band were performed in China. The results showed that the threshold levels for occupational exposure at 0.1 – 30 MHz are in the range of 20 – 100 V/m; at > 30 MHz, in the range of 50 – 200 $\mu W/cm^2$.

(3) Animal experiments. Under certain well controlled conditions of exposure, a variety of behavioral, neurological, reproductive abnormalities, and DNA damage were

newly demonstrated. Evidence for biological effects at SAR threshold of about 0.5–1 W/kg was observed.

(4) Possibility to meet the standards at no cost or low cost. It can be expressed as follows: medical examinations and epidemiological analyses ⇒ evaluation whether or not the really occurring levels of occupational and environmental exposure are safe, and search for the threshold range ⇒ rationales ⇒ making decision of the referential animal experiments ⇒ possibility to meet the standard at no cost or low cost.

Question c) Model for developing standards;

Russia: The model of development of the standard should, it seems to me, include not only principles known to you, but also obligatory requirements on maintenance of the control (in Russia and Bulgaria you see indeed).

China: At last, I should say that the adverse effects of EMF are usually not serious, and developed from adaptation to compensation. So, it should consider the benefits and costs, i.e. the possibility to meet the standard at low cost or no cost.

Question d) Methods for determining compliance

It is advisable that scientists from the East and West should discuss in details the proposals of WHO because they refer to the methodology of standardization which has some differences. Standards must be differentiated for persons working under conditions of influence of EMF (professional exposure) and for the population. When considering the hygienic standards it is advisable that social and economical consequences after their introduction should be taken into account. For this it is necessary to have the concrete methods for assessing these consequences.

One possibility proposed by the Bulgarian team is to use the practice in our country. After developing first draft of the standard it should be sent not only to the specialists in standards, but also to every potential user, officials, ecological and other societies, civil organizations, etc. Similar method is used now by IEEE.

Question e) What to do with isolated data points at specific frequencies

The data concerning effects on separate frequencies necessarily should be taken into account at a substantiation of norms. They should be included in data analysis, repeat the measurements, make the frequency range wider at that point etc.

All studies on isolated and specific frequencies should be included in the database for forming criteria for standards, and to be applied when it would be possible.

Question f) When research data are absent in particular frequency ranges, how and with what degree of confidence can results be extrapolated to other frequencies or intensities

This depends on the frequency range: for very high frequencies this obviously could be done, for low and intermediate frequencies no extrapolation is valid without research results to support it.

Extrapolation of the data may be carried out only in narrow enough frequency range where there are the convincing data significant of similar character of biological effects.

Interpolation within a frequency range where no results exist is (or is not) allowable. The two opposite opinions are from specialists inside the Bulgarian team. The explanation of the impossibility to interpolate data for other frequencies or intensities is connected with the probability to have any unknown resonance or windows effect.
If any extrapolation/interpolation is done studies for proving the results should be conducted by several laboratories by unified methods observing the confidence, reproducibility and comparability requirements to the results.

Question g) Applicability and extrapolation of animal or cellular studies to humans

This question should be discussed further. The data from the animal experiments should be checked and proven with some data related to humans.

Extrapolation of the data in an ideal case should take into account the type, class, kind of biological object, its sizes, form, presence of a scalp, life expectancy. It is especially important for the RFR range above 30 kHz. In a range of frequencies up to 10 kHz (and is especial for a magnetic field of a extremely low frequency range) it much easier as it is possible to use a principle of the induced current density.

In RF range it is necessary for extrapolation to know mainly two aspects:

- Character of absorption of EMF energy by the organism and it's different parts;
- Sensitivity of different systems to EMF exposure, and inform and solvable capability of whole body/system/organ state evaluated parameters.

Question h) Should one standard cover the whole frequency range from 0 to 300 GHz

The scientists give mainly two opinions answering to this question.

The first one is positive. The reason to have one standard covering the whole frequency range is that standard is for human exposure regardless the frequency.

Other opinions are negative answers to the question. One answer is that the selection and division to smaller ranges should be made; especially higher frequencies should be separated from the extremely low frequencies. Experimental data should show how wide these frequency ranges should be. Others are the different criteria for creating exposure limits in different frequency ranges (basic limits).

Third opinion is connected with a positive answer but in the standard it should be clear what kind of rationale and criteria for each frequency range are used.

Another opinion is that it is impossible to have a single standard for the whole range because for most of the subranges we have no sources in practice, also proofs of the exposure limits. This opinion sets a new question: Do we need a standard for such wide frequency range?

Question i) Safety factors: should they address scientific uncertainties in the fundamental research or imprecision in the techniques used for exposure assessment and should they also allow for gaps in knowledge;

Yes, safety factors should be included. They are connected mainly to insufficiency of knowledge of laws of EMF biological effects.

Our opinion is that safety factors are connected with all reasons cited in the question. The other question is: Why 1:10 or 1:50 or there must be other safety factor? That is the reason that we consider that it is very important to address the safety factors to concrete results of studies or to calculations of the uncertainty of equipment, exposure assessment, etc. The coefficient of hygienic reserve should be defined by the sum of particular coefficients accounting for measurement inaccuracy, uncertainty or error of the equipment used for measurement and estimation, prevailing age of the population in the exposure area or at places where human stay is longer, e.g. leisure areas, hospitals, sanatoria, kindergartens, schools, etc. The safety factor should be stated as an important requirement for safety to EMF sources.

Question j) Should standards be one or two tiered – i.e. differentiate between occupational or controlled exposure and general population or uncontrolled exposure;

Yes, they should be because the duration of the exposure is of the great importance here. The reason of this positive answer is that:

- two tiers standards allow implementing precautionary approach;
- the legislation in most of the countries requires different approaches for occupations, and for general population.

No, one standard should cover all population regardless of the type of exposure. One explanation is that people are exposed to RFR 24 hours a day, and standard should cover all kind of exposures.

Other opinion is to have more tiers structure of the standards. As examples: Russia and China (3 – tires, different structure). One explanation: Standards should be different for different categories of EMF exposure. Allocation at two and three categories is necessary to divide the following groups of the exposures - professional occupational exposure, general public exposure and nonprofessional occupational exposure (when people which are not serving EMF sources are carrying out other kinds of works where they are exposed to EMF. Examples: agricultural works near to overhead transmission lines, or maintenance service of planes at the airport).

One interesting opinion is the standard to be divided into two parts (2-tiered standard), but for the general public exposure divided into other two classes (in the China standard): First class exposure limits: Below these levels are safe for permanent exposure and for all people (including infants, pregnant women, old people, patient, etc.). Second class exposure limits: Below these levels a temporary dwelling of human subjects is allowed (factories, organs, parks, recreation areas, etc.). However, living quarters, hospitals, schools, kindergartens, etc. are not allowed to be located.

Other opinion is to separate the standard not by exposed groups but by areas where different exposures are possible. The separation is connected not to the basic parameters of the exposure (for example SAR), but to the concrete risk to humans being

exposed there. Here, we are speaking for zones "controlled" and "uncontrolled" areas, and other definitions. A third area is defined as "allowed to access" for humans only with safety shielded clothes. For the Hungarian standard in the range of 30 kHz-300 MHz the standard defines an additional tier as called "harmless area".

Question k) What about social and economic impacts; should they be considered

They are very important in developing standard and should be considered.

There is one opposite opinion (Yugoslavia) where it is discussed that the economical situation in implementing new technologies could lead to impossibility to apply this principle. In this situation the main aim of the standard should be the health of the people, not the technology.

Question l) Should they be in a form that methods for determining compliance are made easier.

Yes.

Annex 1 - Main Results

China (Prof. Huai Chiang):

There are only 3 subranges /0.1-30MHz, >30-300MHz, 300 MHz - 300 GHz/ for the whole RF in the environment exposure standard limits constant over a wide frequency range (not a slope in f).

Reason:

1. From practical point of view: complexity of EMFs in environment and easy to perform for the inspector
2. Many uncertain issues exist in assessment of bioeffects and possible health hazard. We don't know the exact effects.

Compared with continuous wave radiation, pulsed microwave with the same frequency and the same average power density are generally more effective in producing a biological effect. Stricter exposure limits are adopted for pulsed microwave exposure in the occupational exposure standards. Characteristics of the pulsed radiation (i.e. pulse width, repetition rate, etc) are not taken into account.

Parameters: only reference levels.

Czech Republic:

Yan Musil (former standard): Since 1965 the time factor together with the field level has been included in the Czech standard. Values of the maximal permissible irradiation have been established not only on the basis of available proven knowledge of biological effects. Possible partial biological effects have been also considered as well as theoretical and model studies, which could explain experimentally, found specific sensitivity of biosystems at so called non-thermal levels. From the viewpoint of probable non-linearity of effects, energy cannot be the sole factor at very short exposures and a field ceiling value shall be introduced instead. The frequency dependence of established maximum permissible irradiation is derived from the frequency dependence of the average SAR. There is also introduced safety factor because the scientific knowledge could cover a certain average sensitivity of the organism at active field parameters only.

It is not acceptable to neglect the possible long-term action of low ("athermal") field levels. That was the reason for including the time factor in the former Czech standard.

Parameters: only reference levels, no basic restrictions; maximal permissible irradiation W_E $[(V/m)^2.h]$, W_H $[(A/m)^2.h]$, W_S $[(W.h/m^2)]$; three types of field levels: ceiling field levels, workday-shift and/or calendar day levels (for general population) and shorter period levels (depending on exposure time).

No limits for the frequencies below 60 kHz in the former Order. The frequency ranges covered by the former order are as follows: 0.06 – 3.0 MHz; >3.0 – 30.0 MHz, >30.0 – 300.0 MHz; >300.0 MHz.

L. Pekarek (new standard): frequency range 0 Hz -300 GHz; adopted ICNIRP Guidelines.

Hungary (G. Thuroczy):

The standard covers the frequency range of 30 kHz-300 GHz.

The values of permissible levels between 300 MHz-300 GHz are stricter than ICNIRP reference levels. In the frequency range 30 kHz-300 MHz the reference levels are close to the ICNIRP/EU values after a modification in 1993.

No SAR based basic restrictions, only reference levels. The standard is separated in permissible levels for general public and workers, as defined "controlled" and "uncontrolled" area. A third area was also defined which is "not allowed to access" for humans (only with safety shielded clothes). In the range of 30 kHz-300 MHz the standard defines an additional tier as called "harmless area".

Poland (Prof. St. Szmigielski, H. Aniolczyk): The main rationale of the standard is to protect both against short-term and long-term effects of EMF exposure. Short-term exposures are permissible at field intensities similar or even higher (for certain frequencies) than limits of ICNIRP, while long-term exposures and public exposures are permissible at considerably lower levels that those set by ICNIRP. Additionally, permissible exposure levels for pulsed RF fields (maximum pulse peak power exposure) are also established.

Russia (Grigoriev):

Main criterion for determining the maximum permissible level of exposure is the EMF level, which influence should not cause even temporary disturbance of homeostasis in human organism as well as tension in the protective and adaptive-compensatory mechanisms either in short term or in long term aspect. Maximum permissible levels of EMF are those values that do not cause illness or disturbance in the health status of the population despite their gender or age that could be detected with modern diagnostic methods in the period of exposure or after it is stopped, if the exposure to these values is every day and at the typical for each of the sources radiation regime.

Type of the diagnostic examinations: clinical-physiological, hygiene and special radiobiological examinations shoud be carried out at chronic exposure.

Safety coefficient should be applied. Safety of the population should serve as a basis for the development of a harmonised standard.

Broad examinations regarding the modulation and the delayed consequences are needed to be carried out in the future. There is a possibility for agreement on admiting the existence of non-thermal mechanisms. General agreement for complete safety for the general population with respect to the influence of EMF is needed.

Russia (Rubtsova): By development of standards are taken into account: a range of frequencies - maximum permissible levels (MPL), are developed on a different range of frequencies. MPL, first of all, proceed from a determined threshold of harmful effect, and with entered factor of a hygienic safety, are specifications.

Thus experimental researches on an establishment of a threshold of hazard effect under chronic conditions of experiment and the period after exposure (with registration of parameters of a condition of conducting systems of an organism - nervous, cardiovascular, blood, immune,

studying sexual function and effects to posterity, with the analysis, whenever possible functional and morphological parameters) are basic when the threshold is established on border of compensating ability of an organism including on physiological parameters.

And, in Russian EMF standards for protection of the person three principles are used: protection by time (it is realized in MPL time-dependent values), protection in distance and protection with the help of use of means of protection.

The regulation of pulse fields is fulfilled insufficiently and demands continuation of researches.

Traditionally in Russia hygienic norms of different frequency ranges electromagnetic fields (EMF) are based on results of hygienic, clinical, physiological, experimental studies, as well as on results of epidemiological studies lately. The important part in the solution of the problem of EMF hygienic norms development is the knowledge of the mechanisms of factors' biological effects.

At the first stage of hygienic norms development it is possible to use expected methods. But these methods can be used for preliminary prognosis only.

The main basis of EMF rate setting are the experimental data of the irradiation hazard effects threshold determination with due regard for the results of EMF exposed human health state studies and epidemiological studies as well as the occupational hygienic data including EMF occupational exposure data.

The main criteria of EMF exposure hazard or danger in the evaluation of the results of experimental studies are the determination of chronic exposure effects threshold as well as acute exposure effects threshold. In this concept the determination not only organic damages but principally stable physiological changes of main organism systems (more than two σ difference from control) are very significant.

According to Russian concepts, organism biological effects to EMF exposure (depending on intensity of reaction) is possible to be divided into 3 zones: subthreshold, zone of adaptive perception, zone of an affection.

In a zone of adaptive perception also it is possible to allocate 3 areas:

1) Indifferent (border to subthreshold), 2) area of active adaptation, 3) area of extreme effects. In 1-st area the occurrence minimal, not over norm limits and quickly disappearing physiological changes are possible. In 2) – the effects are more marked and observed not only in the exposure period but in the period soon after exposure too.

In 3-rd - the variety of reactions, long duration functional changes, development of cumulative effects are observed.

According to hygienic rating principles at hazard effect threshold determination expressed functional changes are considered as most important. The threshold of harmful effect is in a border of active adaptation area and area of extreme effects. The threshold of hazard effect can be determined as combination of standardized factor's parameters that induce one or set of following organism changes:

- Qualitative reorganization of vital processes in the organism;
- Any quantitative changes of vital processes outside of physiological norm fluctuation limits that cause the decrease of organism ability to realize the normal compensatory possibilities volume and not allow to equilibrate the adverse effects of another environmental factors of an or unusual psycho-physiological state;

- Development of previous exposures effects summation being cumulative and resulting under long time exposure to vital processes significant shifts that are outside of their allowable quantitative changes.

The regulation of pulse fields is fulfilled insufficiently and demands continuation of researches.

Turkey (Prof. Nesrin Seyhan):

Frequency range: 10 kHz – 60 GHz

Exposure limits are based on the results of international researches. ICNIRP guidelines are the main basis for the Turkish limits. No net criteria about pulsed fields yet.

Safety factors: "safety distance" is taken into consideration in Turkish regulation :

$d = (\sqrt{30.P.10^{G/10}}) \; / \; E$ (meter)

P : output power (watt)

G : antenna gain (dBi)

E : electric field (V/m)

d : safety distance

Annex 2 - Main Results

Czech Republic (L. Pekarek): What seems to me interesting at this moment, is how to estimate the influence of transient low frequency magnetic field and induced currents in the body, using the principles of ICNIRP limits. In cases of transients with characteristic frequencies lower than 1000 Hz, no averaging is allowed, and the possible risk of strong magnetic pulses seems to be difficult to ascertain after the mentioned regulations. "Perhaps the goal, which should be achieved before the unified standards can be reached in the whole word, is to convince all states that they should abandon a national "pride" of its own results and take the opportunity to use results summarized in a common "pool" of scientific knowledge and evaluated for a possible health hazard by an acknowledged international organization. It is clear, that any difference between standards in different countries of the globalized world undermine public belief to scientific knowledge and cause, among many other inconvenient effects, unnecessary expenses.

ICNIRP: adopted ICNIRP in 2001.

Czech Republic (J. Musil): The Czech Republic (and previously Czechoslovakia) has long had some of the strictest RF/MW exposure standards in the world. No more. On January 1, 2001, the Czech government began following the recommendations of the European Union and has now essentially adopted the exposure guidelines of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) for public and occupational exposures. In an open letter to his colleagues around the world, Dr. Jan Musil of the National Institute of Public Health in Prague explained that he opposed the change and that he had been removed as the chair of both the National Reference Laboratory and the Advisory Board on Non-Ionizing Radiation. "I was replaced by a person with no research experience in this area, who was willing to accept the ICNIRP limits without biophysical qualification," he told Microwave News. Musil said that he favors prudent avoidance and that he is against the adoption of the same limits for short and long-term exposures and against the "hurried harmonization of standards without objective verification of the facts." (See also MWN, M/J00.) MICROWAVE NEWS, XXI, 1, J/F 2001.

China (Prof. Huai Chiang): The current RF EMF exposure standards in China have been performed for over 10 years. They have promoted many valid measures to reduce significantly the exposure levels in work places and in environment in China. However, because of the new and rapid development of telecommunication facilities, the economic globalization, and the need for standard harmonization, a draft of the amended EMF exposure standard was proposed by an United Working group in China. It will be further discussed and determined after public review.

(1) As ICNIRP guidelines, the EMF standard draft covers the entire frequency ranges of time-varying EMF and static magnetic field. Also there are two classes, i.e. basic restrictions and reference levels, and the basic restrictions on exposure are current density, SAR (including whole-body average SAR and localized SAR), and power density. Two tier standards, i.e. occupational and general public, are also adopted.

(2) The main differences between ICNIRP and the draft are as follows:

A. ***ICNIRP guidelines*** are based on short-term, immediate health effects such as stimulation of peripheral nerves and muscles, and elevated tissue temperature resulting from absorption of energy during exposure to EMF (thermal effects). However, there is a body of literature, which suggests that biological effects can be shown at levels of radiation, which do not produce heating or stimulation. For non-thermal chronic RF exposure, for example, neurological symptoms, changes in behavior and cardiovascular system, etc. in occupationally exposed workers have been reported in many different countries by some cross sectional epidemiological studies and animal experiments. Though their mechanisms have not been understood yet, many studies in vivo and in vitro have confirmed at least that the EMF exposure at the levels lower than the ICNIRP guidelines may cause stress effect. And chronic expression of heat stress proteins is reported be associated with health hazards. Since there are many potential long-term effects, more stringent basic restrictions than ICNIRP's are adopted in the draft of the amended exposure standard in China. The reference levels of the standard are being discussed.

B. Exposure time is a key factor in how much exposure a person receives within a day. Many studies indicated that the bioeffects of EMF exposure are related to the exposure intensity and duration of exposure. In fact, some localized exposure, e.g. the exposure duration of mobile phone user is usually less than one or two hours per day. The basic restriction for such short time exposure should be different from longer time exposure, that is adopted in the draft of the amended standard. And for occupational whole-body exposure, there are various but regular exposure duration, then in the draft, the EMF permissible exposure reference levels for shorter time exposure are also higher than that of 8 h per day exposure.

(3) The present knowledge in assessment of possible health effects related to exposure to EMF have not provide sufficient rationale for establishing satisfactory and general acceptable exposure limits. The draft of the amended exposure standard in China is also questionable and far from perfection. However, as the rapid development of molecular biology, researches using powerful techniques, such as genomic, proteomics, and others may settle many arguments about the health effects of EMFs. We can identify and understand the biomolecular and sub-cellular effects caused by exposure to low level EMF. We think that it is better for now to provide adequate of protection taking easily achievable, low cost measures to reduce EMF exposure, especially for newly built housing and electrical facilities. However, the EMF exposure standard will be revised.

The reason why such differences exist is the different basic principles of establishing RF exposure standards. There are two types in the world.

(1) The exposure limits was set up based on theoretical considerations of power absorption, which was derived from specific absorption rate (SAR). The SAR limits were according to the changes in rat behavior after the animal receiving acute exposure to RF EMF. A safety factor of 10 to 50 was incorporated.

(2) The exposure limits was set up based on medical examination and epidemiological analyses of personnel exposed to EMFs. It has been demonstrated that chronic exposure to EMFs is associated with a variety of non – specific symptoms. And the results of experimental animals are supplemented with safety factors.

Hungary (G. Thuroczy): The experts and scientists intend to develop a science based and harmonised Hungarian standard and regulations. The idea is to suggest an ordinance covering the whole range (0Hz-300 GHz) to the Ministry of Health with the following concept:

- to incorporate the SAR and J (current density) into the ordinance as basic restriction according to the ICNIRP guidelines in the whole frequency range 0 Hz-300 GHz (no SAR and J in the present HU standard, only reference levels).
- to incorporate the reference levels below 30 kHz according to the ICNIRP. On the other hand using the same reference levels temporarily according to the Ordinance on radiocommunications issued by the Ministry of Health last year in the frequency range 30 MHz-60 GHz and according to the Hungarian standard between 30 kHz-300 GHz.

The Hungarian Standards Institution (HSI) also intends to open a discussion on a new Hungarian EMF standard. This work will start this year (2001). The HSI follows generally the CEN standards, for example all of CENELEC standards will be adopted and issued as Hungarian standard by HSI. Therefore the current CENELEC EMF product and other standard will be also adopted automatically.

Within the HSI an EMF Working Committee is responsible for the decision on all EMF health related standards (not including EMC) according to CENELEC TC 211.

Now the HSI is discussing on a preparation of a new Hungarian EMF standard on the exposure limits relevant to human health instead of the current standard.

The problem is that the EU does not support any "new" standard to the EU candidate countries and the CENELEC does not intend to release EMF standard dealing with exposure limits related to health.

The EMF Working Committee of HSI is responsible to give scientific and expert support to adopt and harmonize all of the CENELEC product and other generic standards which are currently in progress in the EU.

Poland Prof. St. Szmigielski, H. Aniolczyk): Western standards (e.g. ICNIRP recommendations) are based on well established scientific facts and offer good protection against short-term exposures in EMF fields at all frequencies. In general, these standards are also used in Polish national standards for short-term (few minutes) exposures. However, Western standards are not verified for long-term exposures and there exist well-warranted doubts that multiyear exposure at the maximum permissible levels for occupational and/or public exposures might be detrimental to the health status with high probability of such effects. Therefore, it is desirable to consider elaboration of two exposure levels – for short-term and for long-term (continuous) exposure.

The permissible levels of exposure set in these standards are verified in view of the present knowledge and therefore, it may be concluded that these standards will not require amendments. Thus, the ICNIRP recommendations may be accepted worldwide, but only as standards for short-term (e.g. several minutes up to one hour daily) exposure of workers and general public. The most important step in harmonization of EMF standards would be discussion on permissible levels of long-term exposures (8-hr exposure for workers, continuous exposure for general public). This discussion may lead to agreement on setting a permissible level based on known effects of low-level exposures, which could provide reasonable protection in view of the present state of knowledge. In contrast to the permissible levels for short-term exposures, which do not require amendments, the levels for long-term exposures would be a subject of periodic reconsiderations and amendments.

The "West school" of standards does not work on development of standards to protect workers and the public against possible health risks from long-term exposures to EMF fields.

There is an increasing pressure of public groups and organizations in Western countries on revision of existing EMF safety standards and the recurrent response from the standard-setting authorities (ICNIRP, FCC) that the present standards provide adequate (full) protection of health of workers and residents. Those, who criticize Western standards point that numerous experimental and epidemiological data indicating a variety of effects related to exposure at EM field intensities below the permissible levels are neglected.

ICNIRP: Not adequate protection against consequences of long-term EMF exposures.

Russia (Nikitina): In the base of harmonization must be:

- the data of studying the bioeffects of non-thermal intensities;
- results of chronic experiments;
- studying the influence exerted by the factor on the most sensitive organs and systems of the organism;
- the data of studying the remote consequences of the influence exerted by the factor.

In Russia in order to improve the approaches to EMR standardization it is necessary to prepare a new version of the "Methodical recommendations for performing the studies with the purpose of hygienic standardizing the electromagnetic factor".

In order to achieve the consent between different schools it is necessary to come to an agreement about the methodical approaches to standardization of the factor. For this it is expedient to organize a working group of specialists from different countries and to commission them with the development of an agreed methodical document. For harmonizing the standards it will be useful to prepare an agreed adjusted International document entitled "Methodical recommendations for carrying out the studies directed to hygienic standardization of electromagnetic radiation". In order to elaborate this document it is expedient to create a working group consisting of scientists who have the experience of studies in the field of developing the national and international EMF standards.

Differences in the legal status of hygienic standards, use of SAR as a standard refer to problems in the field of standard harmonization in the world. In the West only few studies were performed and are being performed now in order to investigate the biological effects of EMF with non-thermal intensities.

The difference in values of the EMF maximum permissible levels (MPL) approved in different countries and International organizations is connected with the lack of coincidence in methodological approaches to standardizing the electromagnetic fields. As the first stage on the way to harmonization of the standards regulating the terms and definitions is to be made.

So, e.g., denominations of the fixed standards are different: maximum permissible levels, permissible levels, controlled levels, main limits. Such notions as dangerous influence, harmful influence, threshold of harmful influence, threshold of harmless influence, threshold value must be unified. In different countries the juridical status of EMF maximum permissible level is different: it can be of recommendation or obligatory character, in the latter case the requirements to elaborating the standard are more strict. In Russia, e.g., according to the "Law on the sanitary-epidemiological well-being of the population" violation of the maximum permissible level leads to disciplinary, administrative and criminal amenability.

ICNIRP criteria. Standards can be fixed on the base of analyzing the data of special studies performed with the purpose of hygienic standardizing the factor. They must consist of several interconnected stages: hygienic, experimental and epidemiological ones and to be carried out by those scientists who have the experience in the hygienic standardization of EMF. The ICNIRP requirements to performing the high quality laboratory studies for developing the maximum permissible levels are to be supplemented with a demand to substantiate a model of an experiment, in particular this concerns the selected parameters of irradiation (what really existing conditions of the influence on a man exerted by EMF are studied) and a biological object (an animal). These aspects are of importance for extrapolation of the data from animal to man. There are no requirements concerning the duration of the chronic experiment and the period of the aftereffect. The possibility to reproduce the results of experiments by another researchers is a debatable issue. The obligatory and advisable tests are to be formulated. When assessing the data of epidemiological studies it is necessary to evaluate the risk not only of cancer diseases but also of the other pathology which takes the main place in the clinical picture under the influence of EMR. The rightfulness of using SAR, specific absorbed rate, as a hygienic standard is to be discussed. Such approach does not take into account that a living organism consists of systems with a large number of complicated internal connections.

The criteria recommended by ICNIRP for assessing the scientific literature and elaborating the standards regulating the EMF levels can be the base for developing the unified approaches to standardization of the electromagnetic factor. At the same time it is expedient to make several additions and to introduce clarity into some theses of the ICNIRP document. The first comment to the ICNIRP criteria is the following: standards can be fixed basing only on special studies but not on the analysis of scientific publications. Because of objective reasons the results of fragmentary scientific works concerning the EMF bioeffects obtained by different researchers are very often contradictory, revealed changes often have different tendencies. These data are to be taken into account but they must not play a decisive role in fixing the MPLs. Studies directed to grounding the MPLs must be purposeful, consist of several interconnected stages: hygienic, experimental and epidemiological ones and should be performed by scientists (institutions) which have the experience in hygienic standardization. **E.g., in Russia the studies concerning scientific grounding the MPLs are carried out only by scientific institutions accredited by the Ministry of Public Health**. There is a question for discussion: perhaps, within the limits of the international community it is expedient to fix the list of institutions which will develop the international EMF standards using the agreed methodology.

Russia (Grigoriev):

I do not agree with the criteria developed in the Western countries.

If official documents on the maximum permissible levels will be developed in Russia, it is of great importance to have in mind that the agreement of the Russian National Committee for Protection from Non-ionising Radiation on the matter must be received. This I insist on.

The only way to reach an agreement is admitting the existence of the non-thermal mechanisms is the joint work of the Eastern and the Western institutions for standards development.

Of course, **ICNIRP** is neglecting the non-thermal mechanisms and therefore has set very high maximal permissible limits. In my opinion this is the main reason for the differences. Western scientists underestimate chronic exposure, dynamic observations of subsequent bioeffects, the presence of cumulation.

Russia (Rubtsova): Basis of harmonization of standards may and should be a harmonization of opinions in an estimation of the importance for an organism of a degree of biological efficiency of influence of electromagnetic fields.

The western criteria may be used at a substantiation of allowable levels of short-term influences, but not for conditions of chronic exposure. SAR criterion is based only on thermal effects (the most seen and not demanding a special explanation) and does not take into account an opportunity of influence low intensity of EMF.

In Russia it is necessary to develop hygienic rules for magnetic component of EMF in the following ranges of frequencies and for the following categories of influence: 50 Hz - for general public, 10 kHz-300 MHz (0.03-3 and 30-50 MHz excluding) for occupational exposure, for all ranges of frequencies up to 300 MHz for general public, specifications for modulated (including pulse-modulated EMF), specifications for a category of occupational nonprofessional EMF exposure, specifications for combined with other factors EMF exposure.

The coordination between western and east concepts probably when questions of presence of biological effects will be specified at levels lower, than causing temperature changes. Such works last years occur in the west.

The ways of EMF hygienic standards harmonization worldwide could be solved only after achievement of the consent on the following positions:

- Definitions of the uniform approaches to a hygienic evaluation of EMF exposure;
- Evaluation of significance of the results of experimental studies;

- Determination of priority of the EMF biological effects mechanisms (for RF and microwave frequency ranges previously);
- Evaluation of significance of the results of epidemiological studies;
- Determination of the significance of the results of human health state evaluation
- Determination of principles of hygienic standardization of combined EMF exposure of different frequency ranges

Similarly, the basic problem in the coordination of positions of the east and the west - definition of significant biological effects of EMF at the levels which are not exceeding a threshold of temperature shifts.

ICNIRP Guidelines in general have many advantages. However, it is not acceptable the direct mechanistic extrapolation of the approaches based on induced currents and SAR concept, based only on thermal effects. As a result of the direct mathematical (mechanistic) approach, for example, 50 and 60 Hz hygienic norms should be different whereas similar character of their biological effects is known. In Guidelines possible resonant maximum of absorption is not taken into account, the opportunity of biological effects of low levels of a field is absolutely ignored. Besides presence of the basic restrictions and control levels contradicts principle of an establishment of maximum permissible levels more acceptable, in my opinion, time-dependent influences.

Turkey Prof. Nesrin Seyhan): The main criteria for Western standards are SAR values. For this phenomena 1 degree C rise in body temperature is taken as a basis. Unfortunately, for a biophysicist 1 degree C rise is an enormous amount. So we should discuss on this criteria again and answer the question why one degree is taken as a basis. We have not agreed taking SAR as a criteria for putting standards. We should take biological effects of RFR into consideration, also.

My proposal was 4 V/m for 900 MHz and 6 V/m for 1800 MHz. But 10 V/m was taken as standard for 900 MHz and 14 V/m for 1800 MHz in TURKEY by law (12 July 2001).

Limit values of East European countries are good examples for the countries in the stages of establishing these regulations. So it will be convenient to preserve those values in the future.

I hope the limit values of western countries will be pulled down to get to a harmony with the eastern countries.

I think the major problem is the lacking of putting the importance of human health at the center of harmonization studies. So harmonization studies must be based on the criteria of human health. It will not be easy but it is certainly possible.

ICNIRP: We needed such guidelines, as a starting point ICNIRP seems O.K. but we should drive new guidelines taking non-thermal effects into the consideration as soon as possible.

Yugoslavia (V. Drinchic): The agreement between different schools could be in supplementing the East and West viewpoints, but both should be supported by valid experimental data.

STANDARDS AND REGULATIONS FOR EMF EXPOSURE IN BULGARIA

Michel Israel*, National Center of Hygiene, Medical Ecology and Nutrition, Sofia, Bulgaria

The first standard in Bulgaria for occupational exposure to electromagnetic radiation (EMR) dates from 1971. It contained very low levels of exposure: 20 V/m, and 5 A/m for the frequency range 100 kHz to 300 MHz, and 10 $\mu W/cm^2$ for microwaves. The first hygienic norms were introduced directly from the former USSR.

Many changes have been made for these 30 years. Now, our standards look quite different than the ones before.

1. Type of standards

Two types of standards in Bulgaria for EMR human exposure are available. The first type is normal standards, which are not obligatory; the second type is ordinances. Most of the essential standards (mainly the exposure levels) are cited in the ordinances what makes those standards also obligatory.

Two tier standards are used in Bulgaria – for occupational exposure, and for the general population. Different terms and parameters are used in the different exposure standards.

2. Terms in the Bulgarian standards.

♦ ***for near-field exposures- frequency range 0 Hz to 300 MHz:***

- the electric field strength E [V/m]
- the magnetic flux density B [T] to 60 kHz
- the magnetic field strength H [A/m] for frequencies from 60 kHz to 300 MHz;
- dose parameters (energetic loading) - $W_E = E^2.T$ $[(V^2/m^2).h]$, and $W_H = H^2.T$ $[(A^2/m^2).h]$, for the electric and magnetic field exposures, including the time duration T (in hours) of exposure.

Here, W_E and W_H are the whole body incident EMR energy for the time of exposure in the working shift; E and H are the measured field values.

♦ ***for far-field exposure - frequency range 300 MHz to 300 GHz:***

- the power density S $[W/m^2]$;
- the dose (energy loading) of EMR in the microwave range - $W_S = S.T$ $[(W/m^2).h]$. Here, W_S is the whole body incident EMR energy (the energy loading); S is the measured field value, and T is the time duration of exposure, in hours [h].

Dose parameters are used only in occupational exposure standards.

3. Philosophy of standards

The standards for radiofrequency and microwave (RF) occupational exposure includes two types of exposure limits: threshold limit values (TLVs), and maximal permissible levels (MPEs) The TLVs are the maximal values which are the limits forbidden to be exceeded. When the exposure values are below the TLVs the MPEs have to be used. They are the dose parameters, which permit calculations of the time duration of exposure.

For static and extremely low frequency fields (ELF) in Bulgaria are accepted directly the TLVs of ACGIH.

The TLVs and the MPE levels for electromagnetic (EM) exposure in the Bulgarian standards have been developed on the basis of a complex of methods: hygienic, clinical-physiological, epidemiological and experimental methods.

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The exposure limit for adverse effect, which is the TLV, is the border dividing the zones of active adaptation of the organism and pathology using safety factor. The standards for occupational exposures are based on criteria of adverse irreversible health effects on man, outside the physiological norms. Exposure limits are based on many experiments (models, animal and human exposures), clinical and physiological investigations, and epidemiological studies for more than 30 years in most of the Eastern European countries.

The coefficients of hygienic reserve (safety factors) are 1:10 from the exposure level causing adverse effect for occupational exposure, and 1:20 to 1:100 for different frequency ranges for exposure to the general population.

4. Standards and regulations

A. Occupational exposures

a) Regulations:

Ordinance No. 7/1999 – Minimal Requirements for Health and Safety in Work Environment

This ordinance includes hygienic norms for all frequency ranges of non-ionizing radiation: static electric field and magnetic fields, ELF fields (electric and magnetic), radiofrequency (RF) and microwave radiation, visible light (illuminance), laser radiation. The exposure levels for RF, visible and laser radiation are only cited from other standards in Bulgaria.

The ordinance is based commonly on *Directive 89/654/EEC; 89/391/EEC*, especially for EMR.

Ordinance No.8 /1996 - Hygienic Requirements for Working Places with VDUs.

Here all requirements (ergonomic, physical factors - EMR, microclimate, light, etc.) for working places are accepted on the basis of *Directive 90/270/EEC.* The EMR exposure limits are based on the Bulgarian standards for the corresponding frequency ranges for occupational exposures (BNS 14525-90).

b) Standards:

BNS (Bulgarian National Standard) 12.1.002-78. Electric Fields near High Voltage Substations and Lines with Voltage 400 kV and more.

The standard is connected with exposures only to the electric field of personnel working in power substations and lines. The exposure limits are time dependent, based on the former USSR ordinance created by the Ministry of Health and Ministry of Energetics and Electronics in 1972. Time dependence of exposure is accepted for electric field strengths between 5 kV/m (unlimited duration of exposure) to 25 kV/m (TLV).

BNS 14525-90. Radiofrequency Electromagnetic Fields. Permissible Levels and Control Requirements.

This BNS is for RF fields in the frequency range from 60 kHz to 300 MHz. TLVs and MPEs with time dependence of exposure are available.

BNS 17137-90. Microwave Electromagnetic Fields. Permissible Levels and Control Requirements.

The standard is for exposures to microwave radiation. Time dependence of exposure is entered in the standard by using the "energetic loading" parameter W_S.

B. General population

Ordinance No. 9/1991 - TLVs for Electromagnetic Radiation in Residential Areas and for Determining Safety Zones Around Electromagnetic Sources.

In this ordinance there are limits for electric field strength (30 kHz to 300 MHz) and for the power density (300 MHz to 30 GHz). It contains a method for calculating the safety zones around EMR sources in the environment. The document is based on our own practice, and the method for evaluation the hygienic zones - on literature review.

Ordinance No. 9/1994 - Hygienic and Health Requirements for Use of VDUs by Students - in Schools and Outside, Gov. News No.46/1994.

This regulation contains ergonomic and other requirements for the safe use of VDUs. The EMR values cited in are only for emission of radiation, on the basis of the Swedish standard MPR II.

Ordinance No. 7/1992 - Hygienic Requirements for Health Protection of the Residential Areas.

Here are defined safety zones around power stations and high voltage lines on the basis of our own practice and on calculations.

The exposure limits are cited on Tables 1 and 2, and Fig. 1.

Table 1. Standards for EMR in Bulgaria – common data.

STANDARD	FREQUENCY RANGE	PARAMETERS	PURPOSE
Ordinance No.7/1999	0 Hz-60 kHz	E [kV/m], B [mT]	Occupational
BNS 12.1.002-78	50 Hz	E [kV/m]	Occupational
BNS 14525-90	60 kHz- 300 MHz	E [V/m], H [A/m], energetic values W_E, W_H	Occupational
BNS 17137-90	300MHz-300 GHz	S [μW/cm²], energetic value W_S	Occupational
Ordinance No.9/1991	30 kHz-300 MHz	E [V/m]	Population
	300 MHz-30 GHz	S [μW/cm²]	Population
Ordinance No.8/1996	0 - 300MHz	E [V/m], B [T]	VDUs –Occupational
Ordinance No.9/1994	20 Hz - 400 kHz	E [V/m], B [mG]	VDUs-children
Ordinance No.7/1996	50 Hz	E [V/m], Safety zones	Population

Table 2. Standards for EMR in Bulgaria – parameters and exposure limits.

STANDARD	FREQUENCY RANGE	E_{max}, V/m	H_{max}, A/m, mT	S_{max}, μW/cm²	$W_E=E^2.T$, $(V/m)^2.h$	$W_H=H^2.T$, $(A/m)^2.h$	$W_S=S.T$, μW.h/cm²
Ordinance No.7/1999	0 Hz	25000	60 mT	-	-	-	-
	0 Hz -100 Hz	25000	60/f, mT	-	-	-	-
	100 Hz - 4 kHz	$2.5x10^6/f$	60/f, mT	-	-	-	-
	4 kHz - 60 kHz	625	60/f, mT	-	-	-	-
BNS 14525-90	60 kHz - 3 MHz	500	50 A/m	-	20000	200	-
	3 MHz - 10MHz	200	50 A/m	-	3200	200	-
	10 MHz - 30 MHz	200	-	-	3200	-	-
	30 MHz - 300 MHz	60	-	-	800	-	-
Ordinance No.9/1991	30 - 300 kHz	25	-	-	-	-	-
	0.3 - 3 MHz	15	-	-	-	-	-
	3 - 30 MHz	10	-	-	-	-	-
	30 - 300 MHz	3	-	-	-	-	-
	0.3 - 30 GHz	-	-	10	-	-	-
BNS 17137-90	300 MHz – 300 GHz	-	-	1000	-	-	200

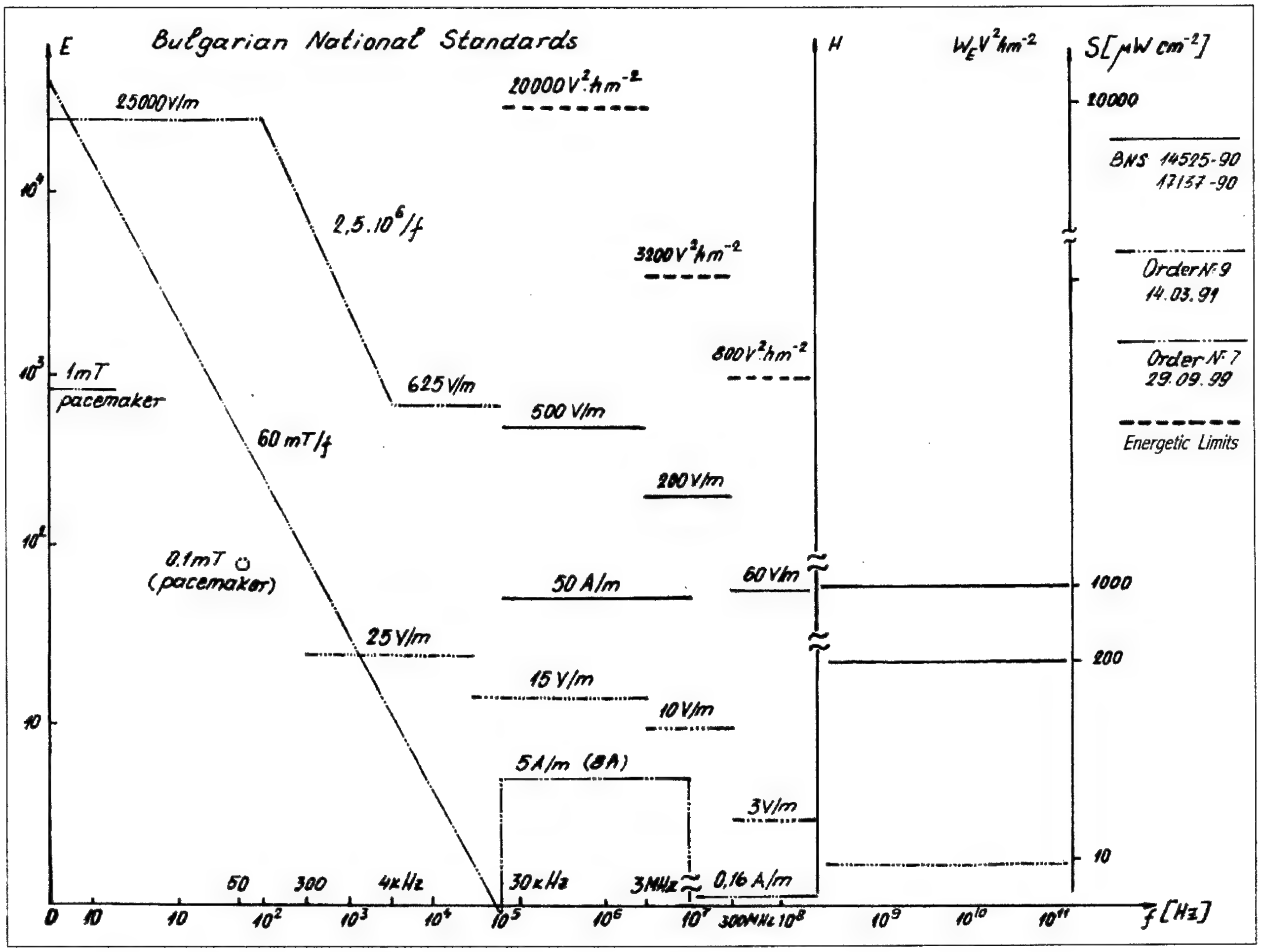

Fig.1. Bulgarian National Standards.

5. Ways for standard harmonization

The first step for accepting other philosophy for developing standards was the translation in Bulgarian language and distribution to the users of the ICNIRP guidelines, and the European pre-standards ENV50166-1 and ENV50166-2.

The purpose of our standards harmonization activities is to be found a way for reaching an agreement between different schools for developing standards. There is a need to develop an agreeable framework for harmonization. The scientific way for developing standards is to reach evidence for exposure limits, and to convince the politics, industry, administration, the public what is safety for the health of the general public. Science needs to be apart from the economic and political issues in these activities.

A step in standard harmonization we think should be to find a way to speak in uniform language (terminological), and to led the specialists from the West Europe, USA, Canada, Japan, etc., to understand the criteria of the East European Standards.

Our opinion for changing the Bulgarian standards is the following:

- We have to accept basic exposure limits on the basis of induced and contact currents, and the SAR values for different frequency ranges. At the beginning, we think it is possible to include these limits on the basis of the East European philosophy.

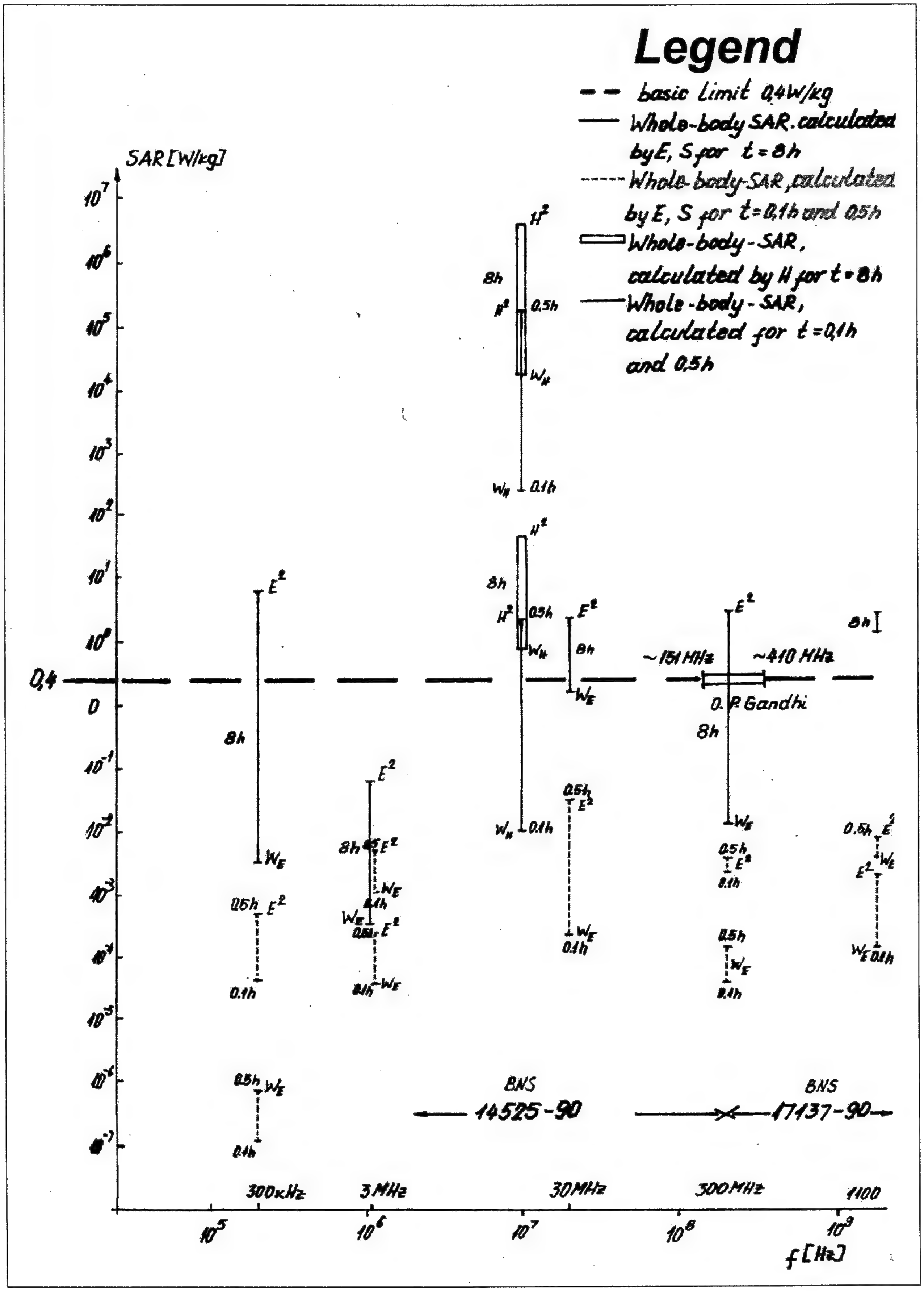

Fig. 2. Bulgarian standards with calculated SAR values.

- We have to change the limits for magnetic fields in our standard for RF because they are much above all exposure limits accepted worldwide in standards. It will be a good way to use equivalent calculated values for plane wave in RF only for far field exposures.
- The dose approach in our standards is a step to the dosimetric approach, and it could be used for future harmonization. Our opinion is that the ICNIRP guideline could be a basis for creating a framework for standard harmonization, and we intend to use it in our future development in this field. Some calculations to compare the dose values in our standards for RF exposure with SAR limits in most of the West standards show that it is not impossible to go in this way. Furthermore, the exposure limits in some frequency ranges especially for the magnetic field are above the limit of 0,4 W/kg (Fig. 2). Some uncertainties in the calculations exist because of the different time of measurement (spot measurements).
- We need, also to develop some technical standards (may be those accepted from the EU) for new technologies, devices and sources of radiation.

Finally, the WHO approach to arrange meetings, workshops, working groups for developing a framework for standard harmonization is the best way to find the desired understanding.

Acknowledgements

The author thanks to P. Chobanov (*Military Hygienic Inspection, Military Medical Academy, Sofia, Bulgaria),* for his help for calculation of SAR values from the energetic loading limits.

EXPOSURE ASSESSMENT OF ELECTROMAGNETIC RADIATION IN THE NEAR AND THE FAR FIELD ZONES. RESTRICTIONS IN THE DOSE EVALUATION

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ABSTRACT

Practice requires measurements in the working space where the resultant electromagnetic field (EMF) is formed by both falling and diffracted fields, and where the emission on the measuring probe has following different components: to comprise the far field in relation to the emitter as well as the near field from re-radiation around the worker. The design is presented with two analytical examples:

1. *Analytical model of EMF in the near field in which model the measuring probe is being set (by amplitude of the signal).*
2. *Comparison of the measurement error and sensitivity of two particular measuring devices for microwave range (calibrated for far field), one with termistor and other with diode probes.*

The analysis provides the following results:

1. *It is revealed that the amplitudes of EMF formed in the near and far field are grouped in one area of the three-dimensional space directed along a coordinate depending on the wave number and in two areas "with visible dispersion on octants".*
2. *The dispersion standardized to the apparatus function and the root-mean-square error present the variances at assessment of the power density at measurement in near and far fields when wide-range and/or nonselective measurement equipment is used.*

It is concluded that measurements and assessments in the near field for radiation from both near and far fields are admissible only when the measurement device is calibrated separately in homogeneous electric and magnetic field.

It can also be concluded that the termistor probe performs more adequately at measurements in the near field. The diode probe can perform more precise measurements in the near field but it requires higher qualification of the operator and a theoretical approach to evaluation of the results. Practically the termistor probe is more applicable in fully unknown circumstances.

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INTRODUCTION

The characterization of the workplace concerning the emitted electromagnetic radiation (EMR) is performed with devices, which are most often calibrated for measurements in the far field (FF). The measured signal corresponds to the current induced on the probe sensor but it can also be "synthesized" by a cascade of radiation (including reflections) generated by the primary electromagnetic flux. This postulates the necessity of:

- minimization of the measurement error in the near field (NF) with a device calibrated in the FF;
- evaluation and minimization of the error between the measurements in the two field zones.

DESIGN

In this paper we propose a theoretical approach at assessment of EMR, measured in near-field (NF) and in far field (FF) with devices calibrated only for measuring the parameter power density (PD).

When EMR intensities are measured in different frequency bands, and at different workplaces using particular device or several devices comparable in relation to their dispersion characteristics, it is recommendable to evaluate in advance implementing numerical methods not only the expected EMF values, but also the expected measurement error. The idea in this case is that such design with preliminary available elaborated assessments of the error would spare time for the further procedure for calculation of statistical quantities for determination of absolute, root-square error, scattering etc.

In order to evaluate the measured EMF values by components (intensities of the electric and magnetic field) for the near field, it is necessary to have the error of the device itself. For this purpose the apparatus function of the calibrated by PD receiver *h'* is introduced, which can be expressed with the following functional relation [1]:

$$\left| E^2\left(\frac{r^2}{R^2}-\frac{1}{1.2\pi}\right)\right| = f\left(r-r_0;h'\right),$$

where *R* is the radius of NF zone; *r* is the distance between the source P_o and the point Q to which the measurement is designated; *r'* is the distance between the source P_o and the origin of the co-ordinate system O_{xyz}; *S, E* and *H* are the power density and the field strengths of the electric and magnetic fields respectively [2].

The main task of the study is to compare uncertainties from measurements at different distances at overlapping of emissions generated by primary sources of I^{-st} order and secondary passive ones of orders 2,3,...N. (***Fig. 1***).

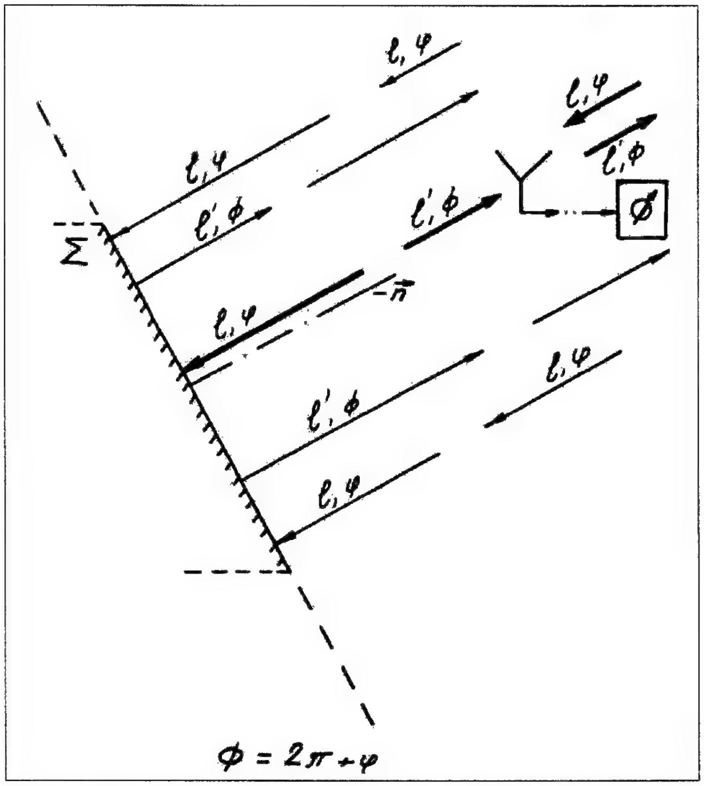

Fig. 1. **Scheme of overlapping of radiation from a primary source and passive re-radiation sources.**

DESCRIPTION METHOD

For the description of the method three particular lengths of the λ waves, three distances to the source and probe direction $1/\sqrt{\lambda.z}$, at predefined constant aperture of the receiver are selected [3];

The direction diagram of a particular source is divided in relation to the signal for which the probe is calibrated according to EMF infrastructure. If an indicator of the increase is introduced for the direction diagram in relation to the distance between the amplitude center and the border behind which there is a wave process, $f=f(z)=f(r.e^{i\varphi})$, or to the observation point, it is possible to shift from assessments in a particular area with correct calibration for the measured parameter (e.g. FF) to assessments in areas with incorrect calibration (e.g. NF). There is, though, a small informal question about the site of the wave front and the distance between two such sites, so that it would be possible to determine according the definition the vectors *S* (power density) and *E* (electric field strength) at a random point in relation to an amplitude, geometric or phase center. The surfaces of the both areas on ***Fig. 2*** cannot be equal and the distance to a random point lying on any of them, *A* - for the physically existing and A_r - introduced by the increase index depends on their curve radius ρ. For geometrically one-plane record in FF we have:

$$A - A_r = (PM)^2 + (PN)^2 + 2(PM).\left[(PN)\cos\left(M\hat{P}N\right) - (PN')\cos\Pi\right]$$

In other words, when using the increase function, the problem of the real phase variance at adjacent spatial points emerges, i.e. the wave area (far field) is not well defined. Physically it is not possible to define really the existing shifting from NF to FF.

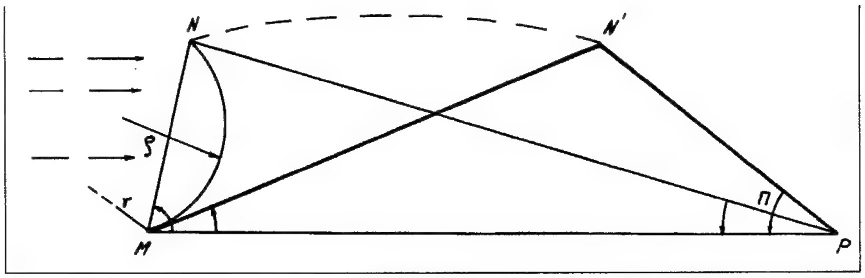

Fig. 2. **Unequity of the two relative points A and A_r in relation to the electromagnetic wave front.**

Fig.3 shows a provisional flat area situated at any distance from the source and from the probe *P*. As the area is finite, a diffraction contour is assigned to it and the existence of a stationary internal point X_o such that the diffraction field is a sum of the falling from P_o field from the "lighted" part of the half-space (P_oOQ), and the radiation from the contour points - the area and its contour is adopted. The angle δ is the angle between the dissemination direction and the outer normal to Σ (Σ is the margin of the probe half-space).

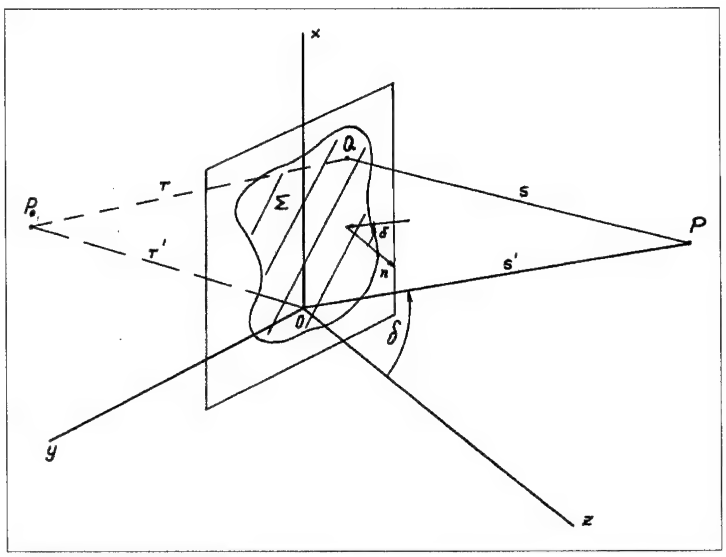

Fig. 3. **Determination of the diffraction contour and internal stationary point X_0.**

Fig. 4 presents the same in relation to a falling "wave" flux through a cross-section of Σ.

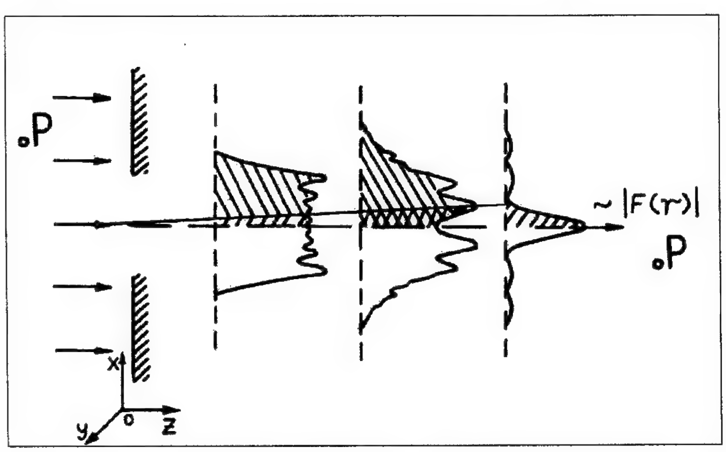

Fig. 4. **Determination of the diffraction contour with internal stationary point – cross-section of Σ.**

Fig. 5 and *Fig. 6* present the distribution of EMF elements (amplitude, phase etc.) depending on wavelength, distance to source (or secondary emitter) as well as on the direction of detection. The gray degrees correspond to the respective three combinations of selected parameters for λ.

Inside each multitude on *Fig. 5* the differentiation of the points depends on the resolution of the method for assessment of the amplitude.

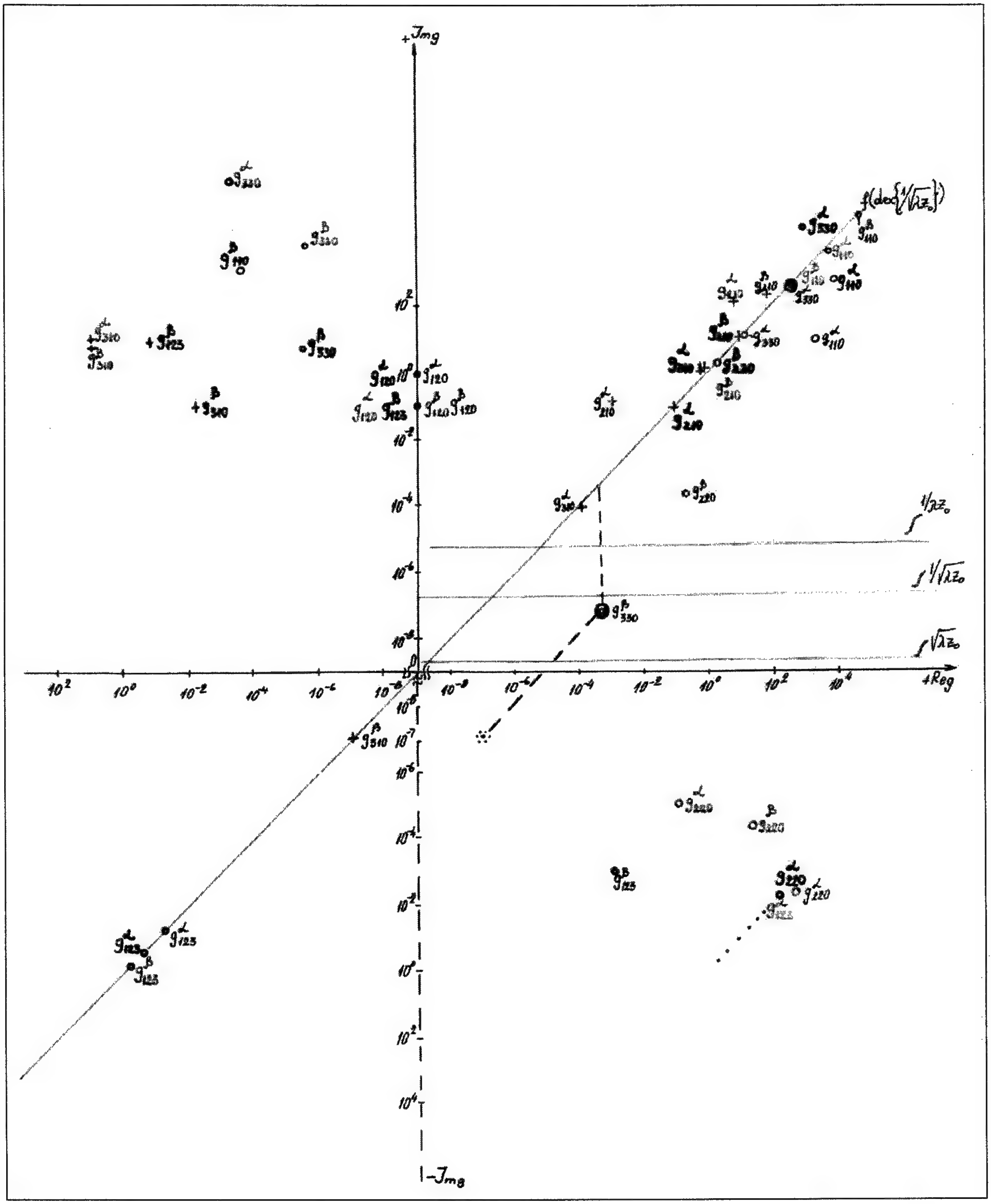

***Fig. 5.* Distribution of EMF components in the coordinates of a real and imaginary part of the signal amplitude – falling electromagnetic wave, according to their dependence on an argument, function of λZ_0.**

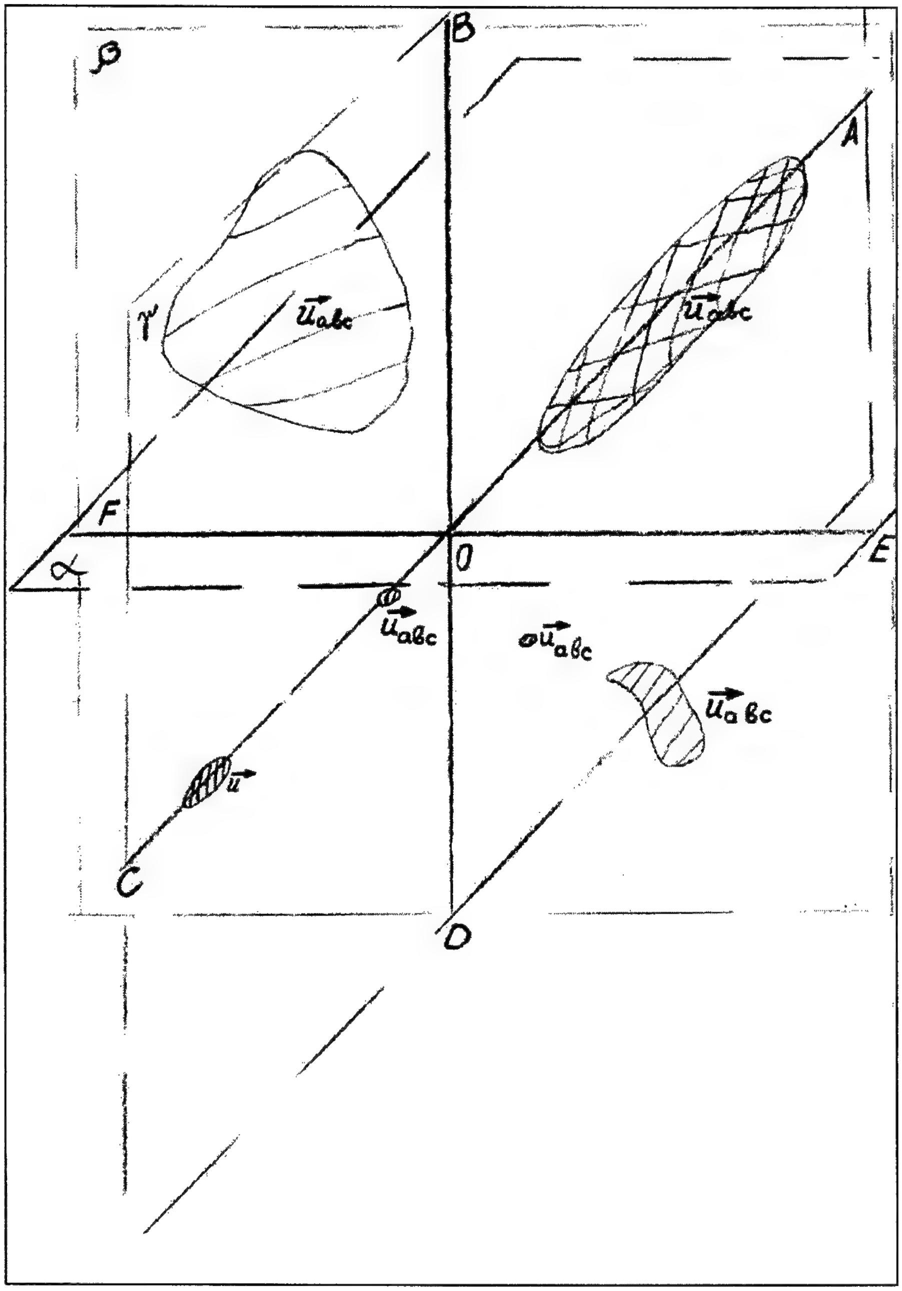

Fig. 6. **Areas of grouping in the different octants of electromagnetic wave components by real and imaginary component of its amplitude depending on the argument – function of λZ_0.**

The argument in the form $1/\sqrt{\lambda . z}$ is a sequence of the presence of phase variances $\Delta\phi$:

$$\Delta\Phi = \frac{1}{\sqrt{\lambda}} - \frac{1}{\sqrt{z_0}}.$$

Fig. *7* illustrates the range of errors of two devices with different probes of EMF calibrated by power density for measurement in NF (in general).

Fig. 8 presents the dispersion measure D of the measurements themselves. The overlapping of dispersions at both types of measurements (with two devices with different probes) is seen. The greater dispersion range at measuring with a diode probe (with RAHAM 495) compared with that at measurement with a termistor probe (PO-1) is clearly outlined. The parameters:

w<1 and $\mathbf{w}^{-1}\leq 1$, distinguish two final provisional cases. It can be seen that, there is a possibility to minimize (reach) min σ and min D.

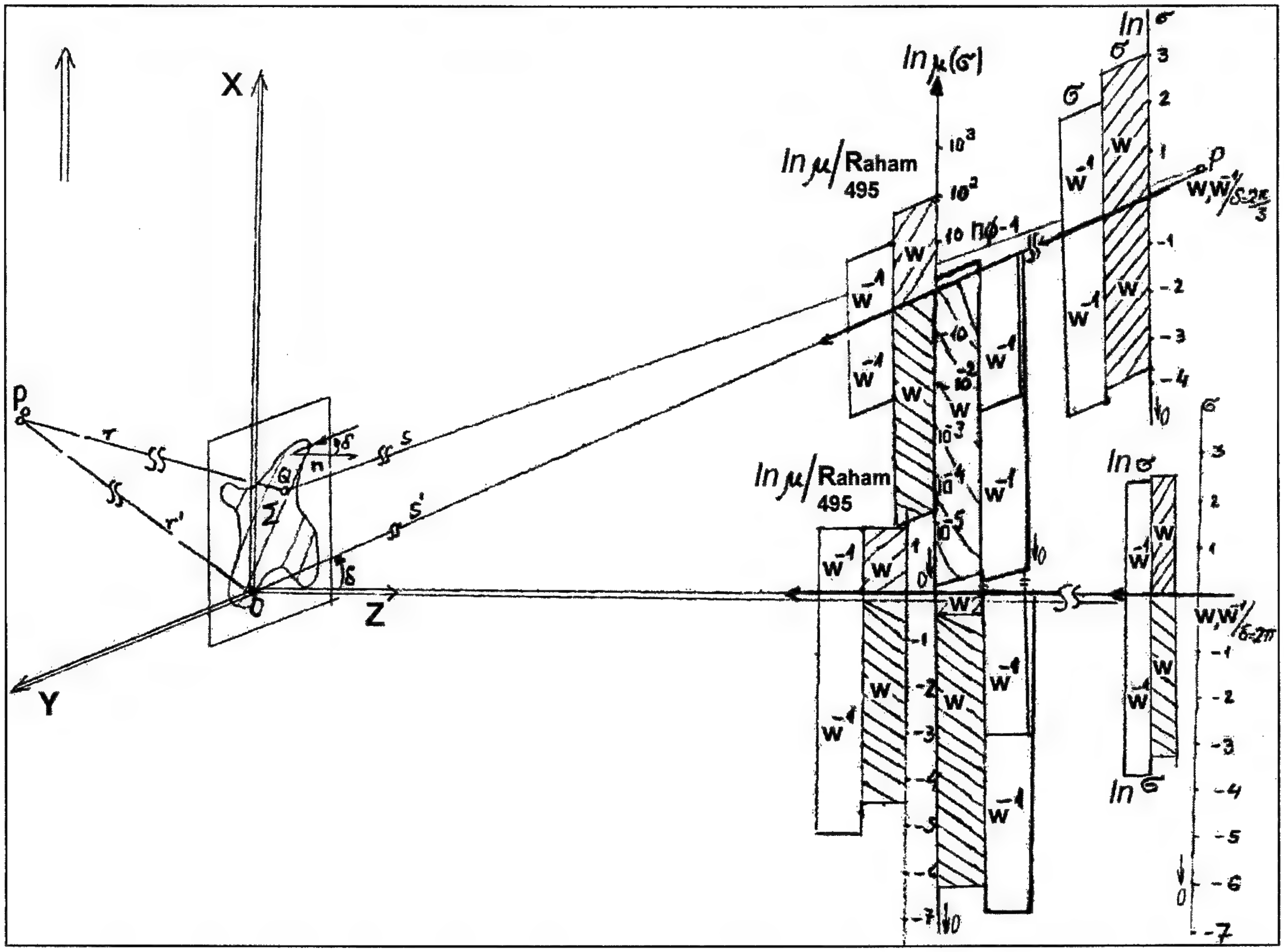

Fig. 7. **Ranges of errors and amplitudes of two devices - “PO-1 Medik” (Russia) with human detector, and “RAHAM 495” (USA) with diode detector.**

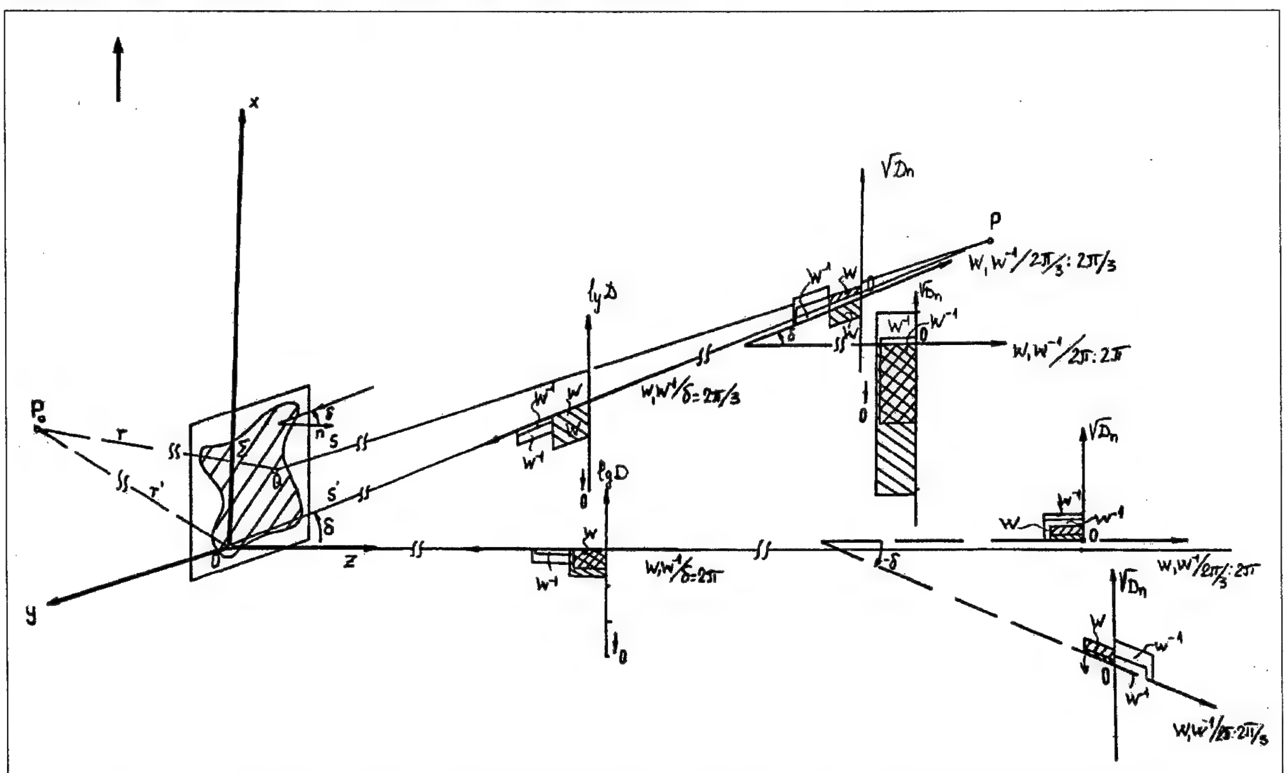

Fig. 8. **Distribution of the dispersion unit of the studies. The double-crossed areas represent the overlapping/inconspicuousness of the errors at measurements with the two devices.**

Fig. 9 presents the standardized values of the measure, $\mu(\sigma)$ which is known here instead the standard deviation σ of the real measurement. The two types of probes determine by the different sensitivity of the two studied devices and by the nature of perception of the signal the necessity of this standardization.

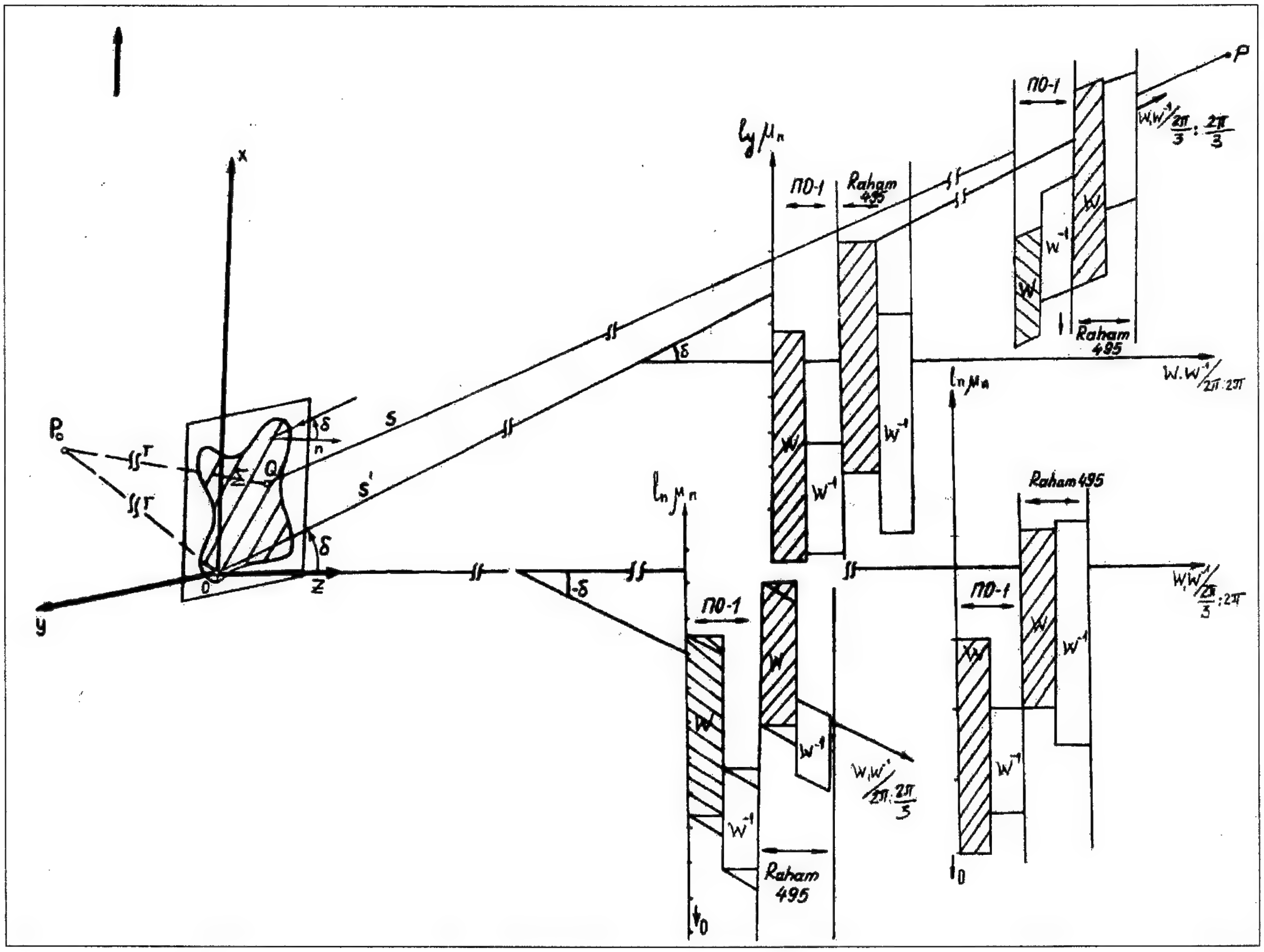

***Fig. 9.* Presentation of root-mean-square dispersion σ at measurement with devices "PO-1 Medik" and "RAHAM 495" through an unified dispersion unit, μ (σ).**

CONCLUSIONS

The calculations for the dispersion of the measurement errors in NF and FF with devices calibrated by power density and at different properties of devices with diode and termistor probes reveal the following:

1. The termistor probe is more adequate for measurements in the near field.
2. The crystal probe enables easier theoretical treating and practical decrease of the measurement errors in NF by the application of numerical methods.
3. The diode probe requires higher specialized training of the operator, measuring EMF; thus the devices with termistor probe are more applicable in on-the-site conditions or at unknown electromagnetic circumstances.

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ONE POSSIBILITY TO SETTLE THE DIFFERENCES BETWEEN THE "DOSE APPROACH" AND SAR VALUES

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INTRODUCTION

Radiofrequency (RF) electromagnetic (EM) human exposure is in the centre of the main research studies in the world. It is connected with the question whether RF radiation is dealing with the increase of cardiovascular, CNS, autonomic nervous system diseases, with cancer, mental and sleep disorders, etc. Most of the new technologies are connected with developing new sources of EM radiation. This is one of the reasons most of the people to be afraid of the RF exposures.

Most of the new standards for RF radiation use the SAR values as criteria for developing limits. The other school, the Eastern European one uses a parameter called "energetic loading of the human body" which is different energetic value characterized the RF radiation exposure. The latter value is a part of the "dose approach" used in the sited standards.

The both parameters – SAR and energetic loading are very similar, and they both are dosimetric values. Calculations from one to the other parameter could be made on the basis of the existing information from the design of the study in most cases. As an example, the way of this how from the Bulgarian limits (the energetic loading parameters) were calculated SAR values it was shown in Varna on the Regional East European Standards Harmonization Meeting. There it was clear that the opinion about "the very strict limits" used in East Europe became only a myth.

OBJECTIVE

Here, we try to make calculations shown the possibility to use the "dose approach" and SAR criteria, both for RF human exposure studies. As examples, calculations of SAR are made on the basis of the energetic loading of the organism for the Bulgarian National Standards limits, and for TV and UHF broadcasting occupations.

METHOD

SAR is defined as the amount of energy W at external irradiation, absorbed by a layer of human tissue TT' with mass m and is characterized, concerning the electromagnetic field, by dielectric permeability $\dot{\varepsilon}_1$ (e.g. in semiconductive tissue with dispersion constant β' and wave impedance $\dot{Z}$ the magnetic flow also is defined

(1)
$$\mu_1 \approx \beta' \dot{Z}\sqrt{\dot{\varepsilon}_1}$$
$$\overline{S} = \frac{1}{2}\overline{EE^*} / \dot{Z},$$

where E* is the complexly conjugated value of the electric field intensity E, $\overline{S}$ is the mean value of Poynting's vector (at permeability μ_1). [3,6] Behind this layer there is another layer, another human tissue with greater $\dot{\varepsilon}_2$. The layers are plane-parallel in the direction of the falling radiation. The radiation from which the tissue accumulates/gathers energy is described by a sinusoidal alternating electric field (EF) which is considered to be tangential to the plane through the tissue layer "$\dot{\varepsilon}_1$". If EF is assigned an intensity E, the average value that is used for assessment of SAR should be:

(2) $$\left|\vec{\bar{E}}\right| = \frac{1}{2}\left|\vec{\bar{E}}\right|_{\tan g}$$

From its dimensions $\left\|\vec{S}\right\| = W.m^{-2}$, and according to the way of introduction, for Poynting's vector it could be set:

(3) $$\left|\vec{\bar{S}}\right| = \frac{\partial^2 W}{\partial A \partial t} = \lim_{V \to 0} \left.\frac{\partial^2 W}{\partial V \partial t}\right|_{A=const},$$

where A is the area of the cross section of the flow, and V is the volume of the flow. According to SAR introduction we have (e.g. in ICNIRP)

(4) $$SAR = \frac{d^2 W}{dtdm} = \frac{d^2 W}{d(\rho V)dt}; \quad V = \left(\sqrt{A}\right)^3.$$

where the commutation dt.dm = dm.dt is equivalently valid to:

(4') $$dm = d(\rho V) = \rho dV = 3\rho \hat{L}^2 d\hat{L},$$

where $\hat{L}$ is the characteristic value of volume. In other words, the conditions are the same – they refer to which quantities and when are interindependant.

From "electric" standpoint:

(5) $$W = U.J.t,$$

where U is the voltage of the EF at particular potential difference and J is the current corresponding to U at a given impedance Z; t is the current time:

(6) $$|Z| = \left|R + j\dot{Z}\right|.$$

If we introduce a frequency-dependent conductivity of the tissue $\sigma_{T,f}$, then

(7) $$W = U^2.\sigma_{T,f}.t; \quad U = \bar{E}.\hat{L}$$

and we come to a chain equality

(8) $$\partial A.\partial\hat{L}.\partial t.\left|\vec{S}\right| = \partial t.\partial m.SAR = \partial^2\left(U^2 \sigma_{T,f}.t\right)$$

On the other hand the energy parameters from the Bulgarian National Standard (BNS), W_E and W_H are defined as [1,2]

(9) $$W_E = E^2.t \quad W_H = H^2.t \quad Ws = S.t \quad 0 < t \le T = 8h$$

Let us then put

(10) $$\left|Z_{TEM}\right| \approx R_e\left(Z_{TEM}^{vac}\right) + R_{f=0}.$$

The basic concept is that the three quantities should determine limits in the "exposure – effect" dependence, and in particular – in the "dose – effect" dependence, up to which the effect is expressed in non-thermal processes, and in the national standards (NS) this refers to human body.

Let us assume the area A to be equal to the effective human body area for a particular frequency f:

(11) $$A = A_e(\text{f; human being body}).$$

Let us make the approximation of the quasi-free space:

(12) $$\left(\frac{E_{\tan g}}{61{,}4.\varepsilon_0\varepsilon_r}\right)^2 = |\vec{S}|;$$
$$[S] = mW.cm^{-2}.$$

This is necessary because in BNS the maximum permissible values for E and W_E, and S are not proportional. Let us introduce the energy measure, W_ε

(13) $$W_\varepsilon = W_E.3600s;$$
$$[W_\varepsilon] = J.m^{-2}.\Omega.$$

We reach the following parametric evaluations:

(14) $$W = \frac{1}{2}.9{,}549_{32}.W_E.A_e;$$
$$W = \frac{1}{2}.9{,}549_{32}.E^2.t.A_e;$$
$$W = 36000.S.A_e.t = 36000.W_S.A_e.$$

Initially SAR has been introduced in the frequency range 151 < f[MHz] ≤ 410

We have the following data for A_e: [3,5]

Table No.1

F, MHz	A_e, m^2
410	0,033 ÷ 2,33
1120	0,098 ÷ 0,997
2890	0,140 ÷ 1,05
4800	0,368 ÷ 1,88
9375	0,495 ÷ 1,22

A_e is defined in an interval, because it depends on the angle between the E-plane and the longitudinal axis of the human body.

We adopt three standard human body weights: 64,8 kgf, 75 kgf, 90 kgf, thus we have the corresponding masses and

(15) $$SAR_i \sim \left(\frac{1}{m_i}\right) = \begin{pmatrix} 0{,}15139 \\ 0{,}13080 \\ 0{,}10900 \end{pmatrix} kg^{-1}.$$

Because of scale adjustment we introduce three ranges of maximal and minimal Ae:

(16) $$A_e.\lambda^2 = const;$$
$$\left(\underline{A_e};\overline{A}_e\right)_1\Big|_{f<410MHz};$$
$$\left(\underline{A_e};\overline{A}_e\right)_2\Big|_{410<f[MHz]<1120};$$
$$\left(\underline{A_e};\overline{A}_e\right)_3\Big|_{f>1120MHz}.$$

These are, for the moment, our limitations concerning the frequency range.

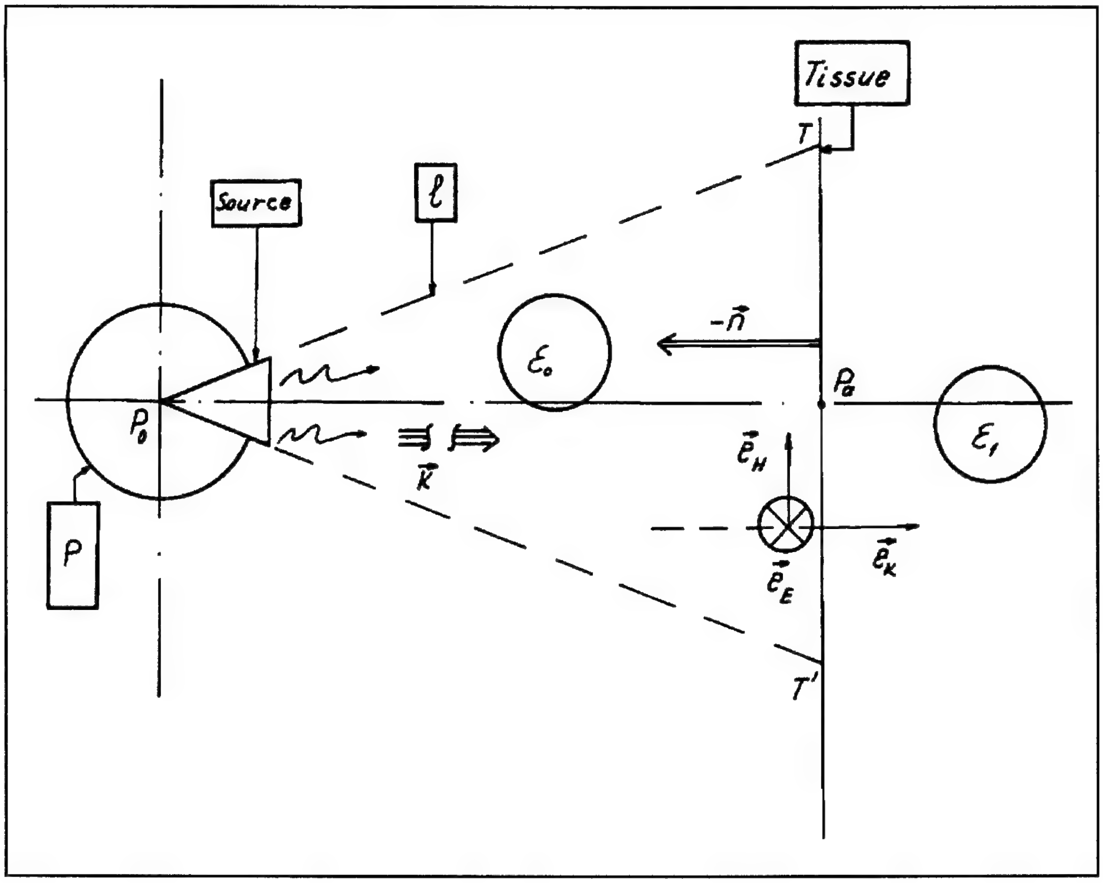

Fig. 1. Chart of irradiation of the border TT' of the front tissue surface according to SAR definition. The falling radiation is characterized by the wave vector:

$$|\vec{k}| = \frac{2\pi}{\lambda};$$

$$|\vec{k}| \sim (\vec{P})^{-1} \sim \left(\frac{\partial \lambda}{\partial t}\right)^{-1},$$

where λ is the wavelength of the falling radiation, $\vec{P}$ is the impulse vector.

The chart represents an irradiation case at horizontal polarization of the electric field with intensity $\vec{E}_{\tan g}$ – frequently encountered situation with mast sources in broadcasting, radar, etc. Respectively the vector of the magnetic field $\vec{H}_{\tan g}$ is perpendicular to $\vec{E}_{\tan g}$ and $\vec{k}$. The three unit vectors form a coordinate system in the half-space of the falling radiation where the dielectrical permeability is ε_0 (in the tissue, behind the border of the TT' sector - $\dot{\varepsilon} = \dot{\varepsilon}_1$;

$$\vec{e}_k \perp \vec{e}_E; \qquad \vec{e}_k \perp \vec{e}_H$$

$$\vec{e}_k = \frac{\vec{k}}{|\vec{k}|}; \qquad \vec{e}_E = \frac{\vec{E}}{|\vec{E}|}; \qquad \vec{e}_H = \frac{\vec{H}}{|\vec{H}|};$$

$$\vec{E} = \vec{E}_{\tan g}; \qquad \vec{H} = \vec{H}_{\tan g}.$$

The flat wave $\vec{k}$ falls perpendicularly to the flat parallel layer and $\vec{k}$ is parallel to the external normal to this layer $\vec{n} \perp TT'$. The radiation source is P and it contains the points of the geometrical axis of the diagram of direction (DD) P_0 vs. which DD is centrally

symmetrical. The point P_a where the spherical wave is transformed into flat wave and the energy irradiated in P is transformed by the source into directed radiation by the main lobe and is restricted to a certain level vs. the initial input radiation power. The conditional border of disconvergence by level for the measured signal is "l" and the amplitude of the signal is equal to that of the falling radiation. The magnitude of the amplitude is determined by the difference between the value of a particular dose effect and the maximal energy by the axis P_0P_a.

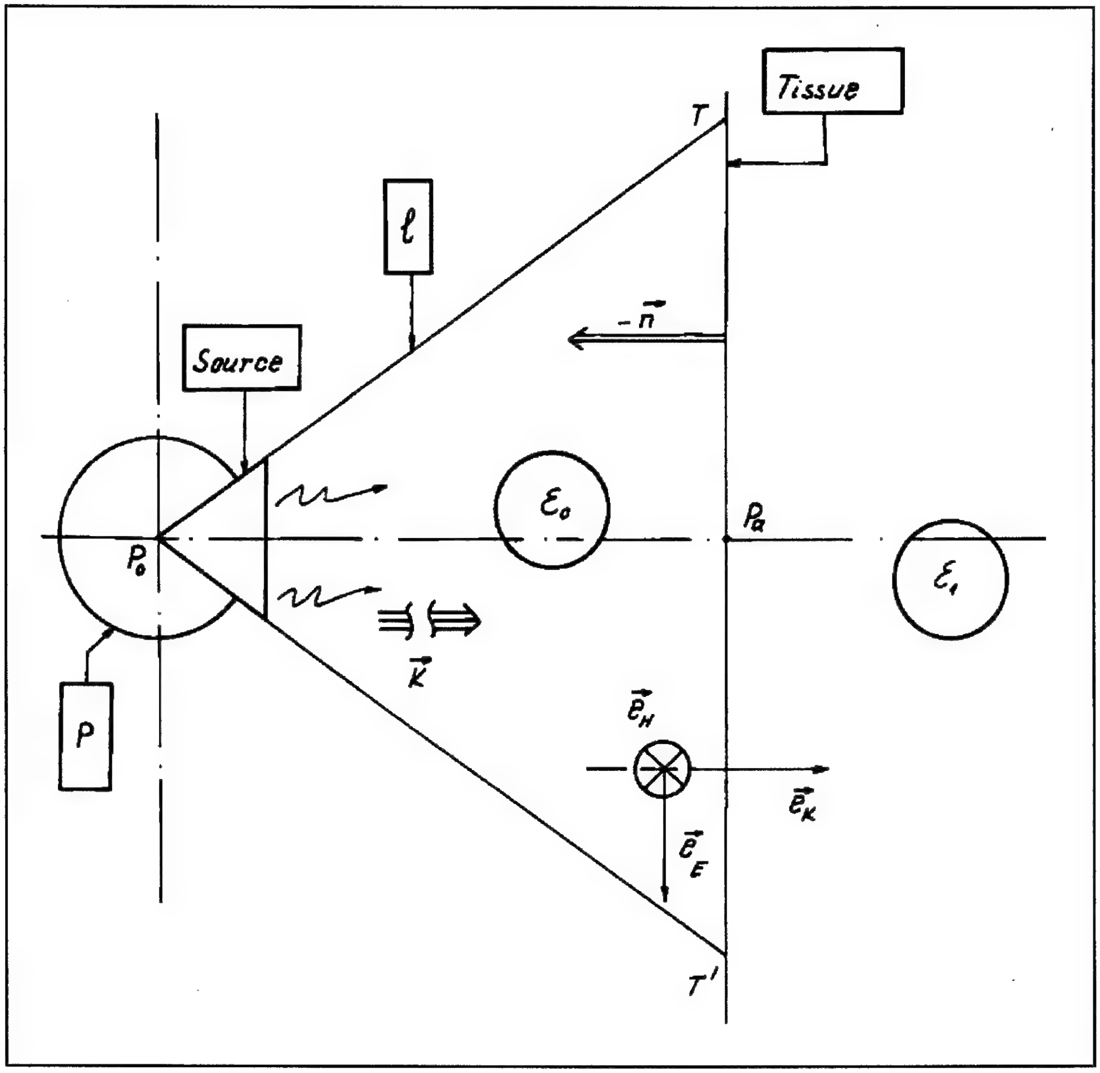

Fig. 2. This chart is similar to that of Fig. 1. Here again $\vec{E} = \vec{E}_{\tan g}$ and $\vec{H} = \vec{H}_{\tan g}$., and the unit vectors $\vec{e}$ are obtained by standardizing E, H and k.

The difference between Fig. 1 and Fig. 2 is the different direction of the vectors $\vec{E}$, $\vec{H}$ and $\vec{k}$ of the flat wave at the border surface of the biological tissue.

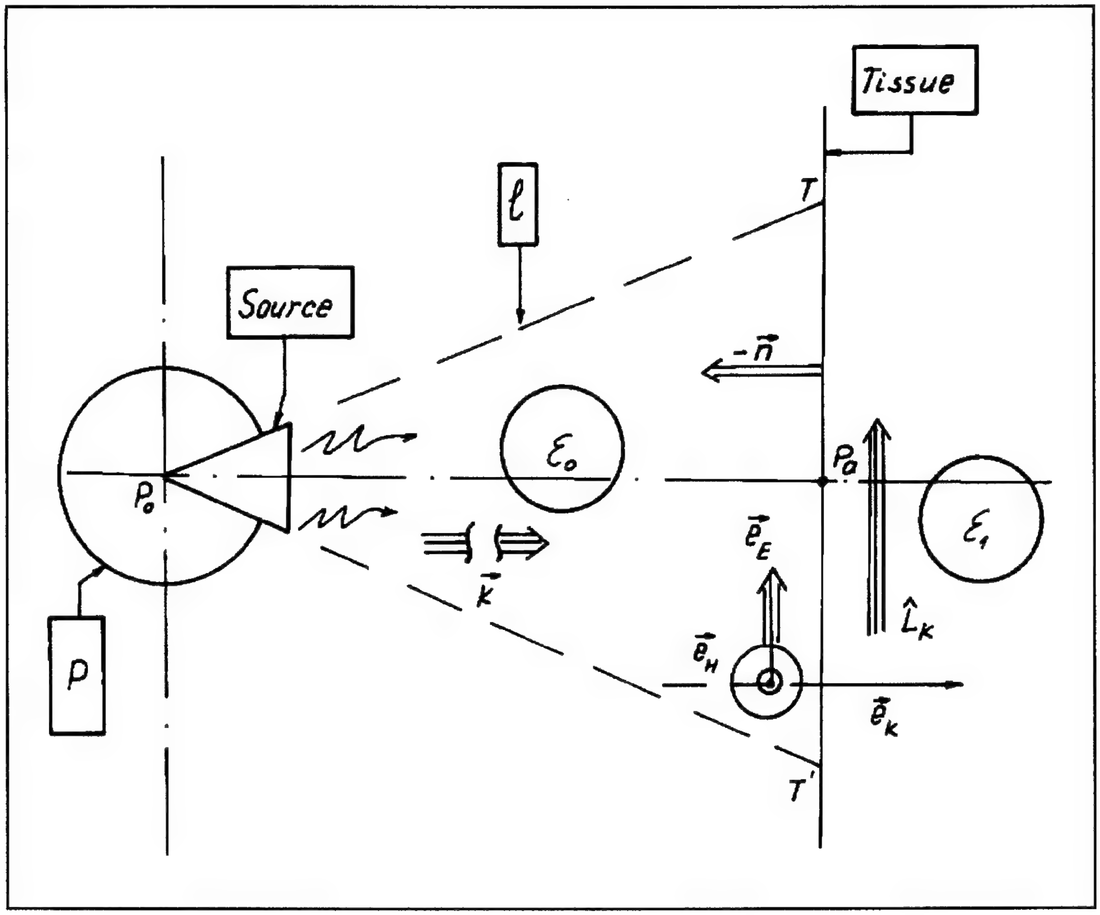

Fig. 3. Here $\vec{E}_{\tan g} \| \hat{L}_k$, where $\hat{L}_k$ is the longitudinal long axis of the human or animal body, imaged as spheroids.

This case corresponds to the maximal deposition of the falling energy and illustrates the case in which O.P. Gandhi et al. [3,4] have discussed SAR vs. basic metabolite rate (BMR) through the benignancy Q which is a ratio of the resonance frequency f_{res} and the active f_{act}, object mass m_T, and the maximal longitudinal dimension $|\vec{L}_k|$, parallel to $\vec{E}_{\tan g}$:

$$\ln SAR = \pm \ln Q + \frac{a}{2}\ln\left|\hat{L}_k\right| - \ln m_T + b,$$

where a and b are coefficients.

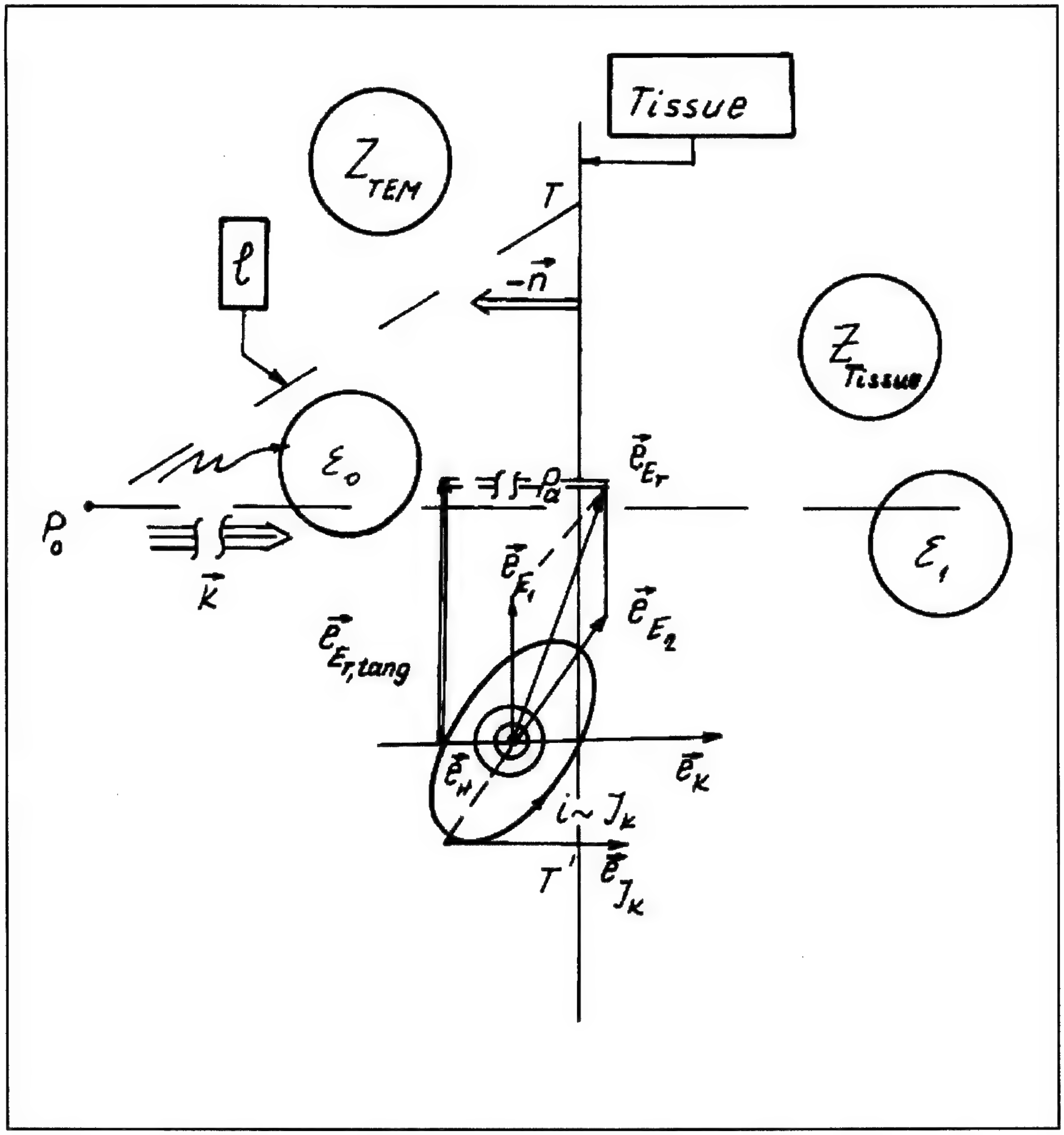

Fig. 4. The chart shows the previous figures in details.

On Fig. 4 the vector of magnetic field intensity $\vec{H}_{\tan g}$ is also a tangent to the sector border TT'. Consequently the vector of the power of the induced electric current, I_k, is parallel to the wave vector, $\vec{k}$. This means that a secondary induced electric field $\vec{E}_2$ superposes with $\vec{E}_1 = \vec{E}_{\tan g}$ and with the decrease of the frequency, increasing tangent components of the resulting electric field appear $\vec{E}_r - \vec{E}_{r,\tan g}$.

SAR definition can be correct also by using $\vec{E}_{r,\tan g}$, but the definitions for SAR by $\vec{E}_{\tan g}$ and using $\vec{E}_{r,\tan g}$, will not coincide by numerical values, for example at averaging in the general case:

$$\overline{E}_{\tan g} \neq \overline{E}_{\tan g} + \overline{E}_2 \neq \overline{E_{\tan g} + E_2}\,.$$

Consequently, if we decompose the human body into several effective flat parallel sandwiches, corresponding to the levels, bound at different altitudes above the earth, $h_{\hat{L}}$,

$\sum_{i,j} h_{\hat{L}_{i,j}} = \left|\hat{L}_k\right| - \sum_{i,j}\left(h_i - h_j\right)\hat{L}$, and select for estimation of the magnitude W_E the maximal $\vec{E}_{\tan g, h_{\hat{L}}}$, we can expect that W_E (also W_H) and whole-body SAR will be corresponding values by a criterion of the type maximal $\overline{E}_{\tan g}$.

EXAMPLE 1

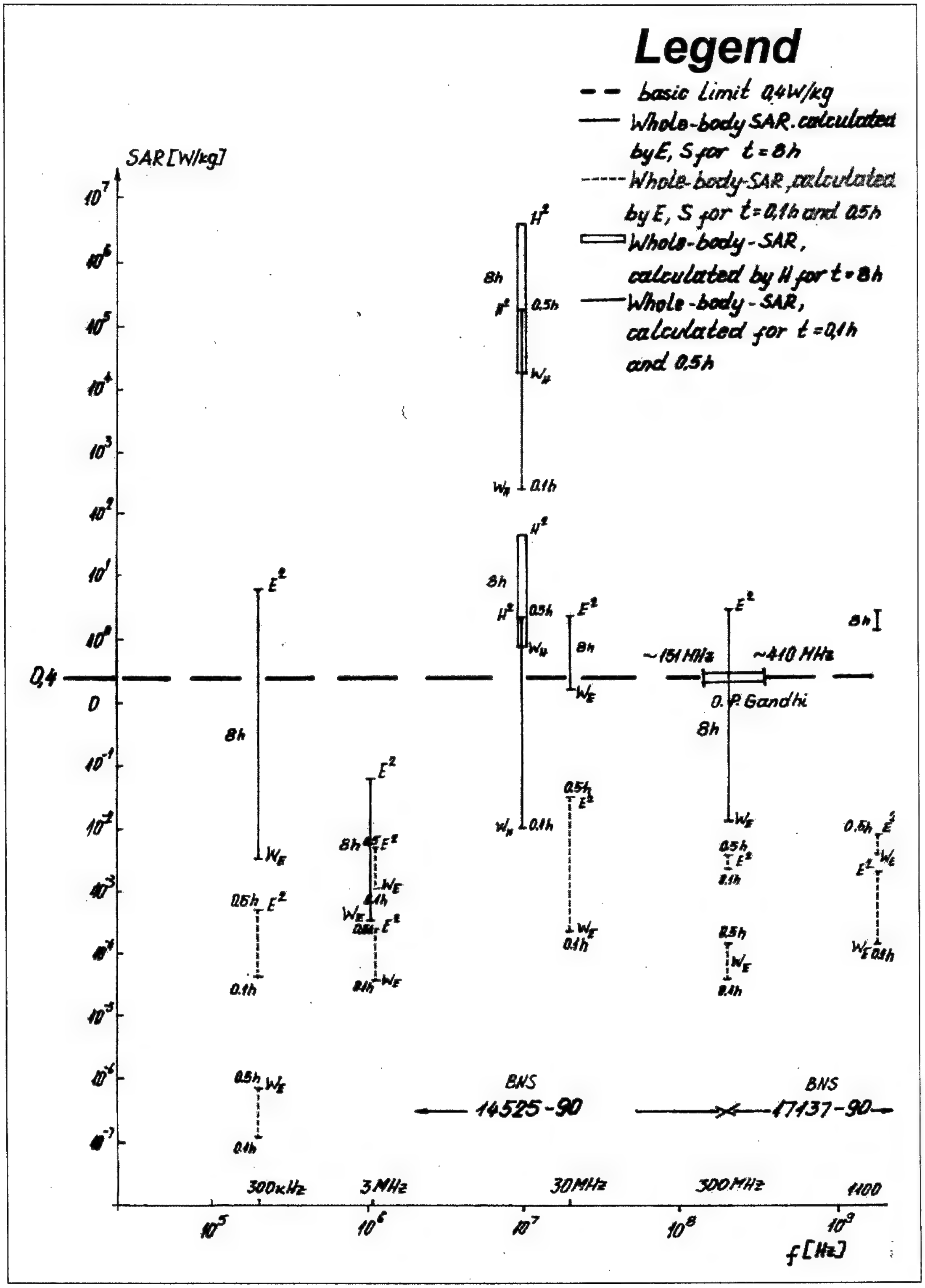

Fig. 5. Our Bulgarian National Standards (BNS 14525-90 and BNS 17137-90) expressed by SAR.

The presentation is within the frequency ranges of the radiofrequency and microwaves, with lower limit 300 kHz, for which it is yet possible to determine a wave vector at appropriate selection of the dimensions of the source, the probe of the measuring device, the distance between them and their interrelating location vs. the baseground.

This is the image of a deposed myth for the conservatism as a protection provided by BNS concerning EMF-exposures:

The dashed line parallel to the abscissa through SAR = 0,4 W/kg outlines the limit up to which SAR values still correspond to non thermal effects.

Above the limits of the frequency ranges, corresponding to BNS, "bars are hung" – the lower point of the bar corresponding first to SAR for a human body weighing 90 kgf, and the upper one is for weight 64,8 kgf, the mean being for 75 kgf weight. Because the threshold intensities (E and H) do not coincide precisely with

$$E = \sqrt{\frac{W_E}{T}},$$

$[W_E]=V^2.h.m^{-2}$; $[T]=h$; $[E]=V.m^{-1}$, separately are taken for calculation of maximal permissible intensities (E and H), the maximal permissible energy parameters (W_E and W_H), and the maximal permissible power density, S. The times T are:

- the officially adopted measurement times – 6 min and 30 min (cumulation for dose evaluation);
- officially set in BNS 14525-90 time for validity of the values from the standard – T = 8h.

For the sector of the frequency range above 300 MHz the values of E^2 and W_E are obtained from S.

For the time interval T = 8h the lower limit of the bar is minimized for the minimal weight and for W_E, respectively W_H, while the upper limit is maximized for 61.4 kgf and E^2, respectively H^2.

EXAMPLE 2

As other example, exposure assessment of EMF human exposure to personnel working in broadcasting made on the basis of the energetic loading parameters was calculated to SAR values. The assessment of SAR was made on the basis of the following assumes:

1. There is an effective surface of the human being, situated in EMF, varying depending on the frequency of the falling wave - A_e (Table 1).
2. At frequencies below 300 MHz for calculation of whole body SAR are used the final frequencies of the subranges 30 kHz…3 MHz (3 MHz), 3…30 MHz (30 MHz) and 30…300 MHz (300 MHz).
3. At the time of exposure the large axis of the human being is parallel to the falling electromagnetic energy, i.e. the receiving aperture is linearly equally "lighted".
4. The main quantity of energy (83%) is concentrated within the human body margins if it would be equal in surface to a flat silhouette.
5. The determined value of SAR concerns the whole frequency range under the frequency for which it is calculated.

The method for calculation of whole body SAR was the following:

The following known relation was used

$$|SAR| = \frac{\sigma_t}{2\rho_t}|E_t|^2$$

The values of E_t were calculated for the corresponding frequencies, effective areas at previously calculated values of the energetic load of the organism:

$$W_E = E^2.T\ [(V/m^2).h];$$

$W_S = S.T\ [\mu W/cm^2.h]$.

The latter were calculated for body weight of 75 kgf, and for three respective groups of people working in TV and UHV broadcasting stations. The calculations were made for the three groups by shifts for 24-hours, regular 8-hour shift and for "other" staff members, working also 8 hours a day, as a control group (with very low levels of exposure).

Table No. 2. SAR and SA values compared with energetic loading ("dose approach")

Group personnel Shift/duration, T, h	**Frequency, MHz Down/upper limits**	**W_E [$V^2 m^{-2}.h$]; or W_S [$\mu W.cm^{-2}.h$]**	**SA $J.kg^{-1}$**	**SAR $W.kg^{-1}$**	**W_E/T, h Or W_S/T, h**	**$W_{E,max}$ Or W_S, permiss. Quotient/time**
1	2	3	4	5	6	7
Main/24 h	3,00	4502,5	14,135	0,58896	18,771	0,7/24 h
	30,00		1413,5	58,89583		
	30,00	271,2	72,6	3,025	9,63(33)	
	68,0 – 71,0		398,3	16,221		
	68,0	19,2	32,3	1,345833	0,8	
	88,0		0,659	0,02746		
	88,0					
	300,0		7,555	0,3147916		
	300,0		0,2323	0,009677		
	410,0		0,43395	0,018081		
	470,0		0,00635	0,000265		
	1120,0		0,201	0,008375		
Main/8 h	3,00	992,7	3,1175	0,389688	124,0875	0,21/8 h
	30,00		311,75	38,96878		
	30,00	60,7	72,6	9,075		
	68,0 – 71,0		389,3	48,6625		
	68,00	6,4	10,75	1,34375	0,8	0,21/8 h
	88,00		0,218	0,02725		
	88,00		0,659	0,082375		
	300,00		7,555	0,944375		
	300,00	26,8	0,07738	0,0096725	3,35	-
	410,00		0,14460	0,018075		
	470,00		0,01180	0,001475		
	1120,00		0,06701	0,008377		
Auxiliary/8 h	3,00	499,3	1,565	0,195625	62,41	0,19/8 h
	30,00		156,5	19,5625		
	30,00	38,7	12,15	1,51875	4,838	
	68,0 – 71,0		65,2	8,15		
	68,0 – 300,0	0,0	0,0	0,0	0,0	
	300,00	27,2	0,01907	0,002383	3,4	
	410,00		0,1513	0,018913		
	470,00		0,022	0,00275		
	1120,00		0,0701	0,008766		

The calculations for the respective subranges, in which the Bulgaria hygienic norms are limited, show the following values (Table No.2). This table shows also the calculated SAR

values. This is a comparison table by different frequencies related to a 75-kgf man in real conditions as belonging to a personnel working in radio and TV communications. In order to be comparable by energy load, the evaluation is presented in W_E; excesses over $W_{E,max}$; by SA and by SAR. The values are averaged by SAR ($\underline{A_e}$) and SAR ($\overline{A_e}$). It should not be omitted that these values are really decreased because of measurement duration.

CONCLUSION

We have to mention briefly as a conclusion that this approach could be one possibility to find tangents between different schools for developing standards.

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CONCLUSION. PROGNOSIS.
IDEAS FOR EXTENDING THE ACTIVITIES

This project gives us the opportunity to generate some conclusions. They are connected with future possibility to develop a framework for international standard – the main idea of the WHO International EMF Project, in the part of standards harmonization worldwide.

First, it is impossible to say that replication of studies carried out in the past 20 to 40 years in the East countries would bring the world to the aims: understanding between the west and east schools for developing standards, and giving a proof for using the lower limits proposed by the east standards in the past.

One reason is that most of these studies could not be replicated because of the different viewpoints about the thesis what should be a good protocol/design of a study conducted before. My opinion is that this protocol (the past one) was much more precise than the used now because of the need to receive results in the beginning of this science – the biological effects of RFR. There was very detailed methodological handbook developed from the east specialists in the 60-70-s being followed very precise in carrying out the research for developing exposure limits. Of course, there were many redundant requirements and investigations cited in this methodological handbook for studying the RFR biological effects.

Second point concerning impossibility for replication of the old studies could be the lack of adequate dosimetry in the meaning of SAR measurements or calculation. The cited parameters (SA, SAR) have not been created in the time of implementing the studies. This doesn't mean that there has not existed a good dosimetry in this time. Every study was carried out with observation of energetic parameters, and SAR or SA could be evaluated from them using different assumptions following by calculations. One example for numerical method to pass from "exposure dose" to SAR.t is developed here, in our report (for whole body exposures in some epidemiological studies).

Other viewpoint is that replication is impossible because of the impossibility to repeat all conditions followed up by the time of the experiment, especially the co-factors, the surroundings, the old measuring equipment and exposure system, etc.

Second, there is an opportunity to reach an agreement between the west and east schools. This project gives us a chance and counts up these possibilities.

One of them is to develop an international working group including specialists with different viewpoints. Here, the first step of this point is completed. This working group should be enlarged and/or specified.

Another idea, discussed here, is the need of developing a new methodological handbook showing the way studies for developing exposure limits should be carried out precisely. This handbook is possible to be prepared by a working group from different countries.

The third requirement for an agreement is to have universal terminological glossary in the field of standards. It should be prepared very fast because it would give an opportunity to speak in one language.

About the criteria for exposure limits: there is a possibility different energetic value to be calculated from one to other and to have universal meaning. This is one of the possibilities to compare the exposure limits between different standards in the world. Another point is that most

of the east specialists believe in SAR criteria (mainly for short term exposures), and we have to do all our best to convince the west ones to understand the criteria for the long-term effects.

First step to an agreement could be to use the ICNIRP Guidelines for criteria for short-term exposures in most of the countries. Later, the criteria could be changed or enlarged but we should have a first step in this process.

One of the possibilities to reach an agreement is also to ask every country to answer the questionnaire proposed by WHO for preparing a framework for developing standards. This was made here, in the Project for most of the Eastern European countries, also China and Turkey. If somebody looks at the replies he could see many common viewpoints.

There would not be an agreement in every point of view if the two schools of specialists for developing standards if they don't reach a consent for including in the standards (or in the criteria for developing exposure limits) the: long-term effects, non-thermal, athermal effects, physiological and psychological parameters changed by the RFR exposure. Other question is (it should be discussed) the including of "windows", "resonance", "informational" effects, also those found in the CNS, cardiovascular, immune, autonomic nervous system.

Our suggestion to continue the research project is in the points as follows:

- To continue organizing (filling up and specifying) the working group for developing an universal terminology, criteria, a framework for standard;
- To enrich the database of studies with a good protocol (on one hand for translating in English, on the other hand, for their future probable replication);
- To continue the attempt of comparing different energetic values used in world studies: experimental *in vivo*, *in vitro*, epidemiological, animal and human exposures. In this point different numerical methods would be developed to calculate SAR from other energetic values;
- To find a possibility (to apply) for co-operation between two or more countries including the East European ones for working together in the field of standard development;
- To collect an information of answers to the WHO questionnaire from most of the countries in the world, and to use them for developing a framework for an international standard;
- To specify the requirements for a good protocol for developing exposure limits;
- To try to clarify the effects of the long-term, non-thermal effects, also where is the limit for an adverse effect on RFR exposure studying the changes in cardiovascular, autonomic nervous system, immune, sexual and other systems of the human body;
- To try to find additional tangents between different schools, and to use them for harmonizing the standards.

One reason for this suggestion for future extending the project is that at the Moscow meeting a roundtable for standard harmonization will be organized, and there the created working group will discuss most of these topics. This will be (after the project) a beginning for searching the way for harmonization in the East countries.